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FUELING THE DRAGON:
ENERGY SECURITY IN CHINA;
IS THERE A ROLE FOR US POLICY?

by

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Many authors talk about the rising power of China and the "China threat." One area where conflict has frequently been predicted is in China's pursuit of energy security. This thesis explores China's energy situation, options available to meet rising demand, environmental impact of these options, and possible ways to mitigate these effects. The thesis then determines to what extent China will be unable to meet its needs from domestic sources and have to look overseas. Then, a review of China's most likely overseas suppliers will explain where China's actions could be threatening to U.S. interests, and where fears are overblown. The areas where concern is most warranted is in China's increasing dependence on imports for its oil needs, and its continued reliance on coal usage. The desire to ensure secure oil supplies has led China to deal with Iran and Iraq, despite U.S. desires to isolate these nations. China is also increasing its influence throughout the Middle East, Central Asia, South America, and retains claims in the South China Sea. While actions in these regions are not necessarily threatening, U.S. policy can play a role in keeping it that way.

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FUELING THE DRAGON:
ENERGY SECURITY IN CHINA; IS THERE A ROLE FOR US POLICY?

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ABSTRACT

Many authors talk about the rising power of China and the "China threat." One area where conflict has frequently been predicted is in China's pursuit of energy security. This thesis explores China's energy situation, options available to meet rising demand, environmental impact of these options, and possible ways to mitigate these effects. The thesis then determines to what extent China will be unable to meet its needs from domestic sources and have to look overseas. Then, a review of China's most likely overseas suppliers will explain where China's actions could be threatening to U.S. interests, and where fears are overblown. The areas where concern is most warranted is in China's increasing dependence on imports for its oil needs, and its continued reliance on coal usage. The desire to ensure secure oil supplies has led China to deal with Iran and Iraq, despite U.S. desires to isolate these nations. China is also increasing its influence throughout the Middle East, Central Asia, South America, and retains claims in the South China Sea. While actions in these regions are not necessarily threatening, U.S. policy can play a role in keeping it that way.

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EXECUCTIVE SUMMARY

There has been extensive literature in recent years about the rising power of China and what this means for the United States. "China threat" writers cover a wide range of activities in China and attempt to show how the U.S. and China are heading towards conflict. While these authors raise some valid points, they seem to be searching for a threat where one may not exist.

However, one tangible area of possible conflict is in energy. Most of the industrialized world's energy comes from finite resources. These sources are very important to U.S. interests and, as the Persian Gulf war demonstrated, the U.S. is prepared to go to war to protect them. China has long been viewed as the last frontier for capitalism with her 1.26 billion "consumers" waiting for modern products. At long last, some of these dreams might be coming true. China is becoming increasingly involved in the world economy, something that most observers see as positive. Where the concern arises is when China's growth and U.S. growth cannot both be sustained due to limited energy sources.

This concern has been highlighted in numerous recent articles, which raise the concept of energy security. This can be generally defined as ensuring that a country has a consistent, uninterruptible, and affordable supply of energy sufficient to meet its national objectives for the foreseeable future. In the case of China, affordability is subordinate to security. Demonstrating the policies China is pursuing to obtain energy supplies will show that price appears to be unimportant to China as they aggressively outbid Western oil companies to obtain oil rights in Central Asia and South America. This attitude

derives from what China has called the "century of shame." During this period of "unequal treatment" and domination by outside powers, China developed a strong sense of insecurity, and a desire to avoid future Western influence. This is a driving principle in China's current foreign relations, and is reflected in its energy policies.

The increasing importance of energy security to the U.S. was reflected in April 1995 when the Institute for National Strategic Studies of the National Defense University conducted a strategic forum on energy security. In the forum's summary, three recommendations were made, two of which are important here. The number one concern was that the "U.S. government needs to pay close attention to long-term prospects for Chinese oil imports" reflecting that country's growing importance. The second recommendation indicated the importance of Persian Gulf oil to U.S. needs in stating that the U.S. must have a robust capability to defend this oil from any threat. This seems to set the stage for potential conflict between the U.S. and China over energy. The likelihood of any such conflict occurring can be determined by a thorough review of China's energy options.

This thesis explores two possible future scenarios for China's energy industry: high and low growth. The general trend is that if low growth occurs, China's actions will likely continue on a course quite similar to the one apparent today. There will be some changes in the energy sector, but overall needs can be met. If the high growth occurs, China will be faced with drastically increased oil and gas imports, and Beijing may fear the security implications that result from this dependence. This scenario could lead to tensions in the Middle East, Central Asia, and the South China Sea.

Fortunately, while China's economy is still growing, the rate of growth appears to be slowing. At the same time, the country is emphasizing efficiency and conservation. These efforts will help reduce the overall demand for energy supplies and slow the rate of growth in the energy industry. This makes the low growth scenario the most likely to occur. Even so, there will be an increase in demand for oil and gas imports that will have China interacting more frequently in world energy markets. Where there is interaction, there is always the possibility for disagreements. The U.S. must be sensible in dealing with China to keep Beijing comfortable with dependence on the world market. If disagreements are allowed to become conflicts, any alternative avenues that China may be likely to choose will be much more damaging to U.S. interests.

In the next few years, China's energy situation will evolve slightly. Oil is becoming increasingly important, and its share of TCEC will likely increase. This increase will be met by imports. Natural gas will also increase its share of TCEC though very slowly. This could be accelerated, and most observers would like to see this done. The main barrier to this is China's emphasis on security above other concerns. This has led to actions that prevent China's indigenous gas industry from realizing its potential. These fuels will be in such high demand for industrial, transportation, and residential uses that they will not be available to assume greater shares of electrification.

The U.S. can assist China in meeting future energy needs by further encouraging American firms to participate in hydropower and nuclear plant construction. These are two areas that stand a realistic chance of increasing their percentage of TCEC, thereby reducing usage of coal. If planned goals are met in these two areas, the need to burn

almost 70 Mtons of coal per year will be averted. These offer the best short-term chance for lessening China's impact on the environment. Fears of proliferation from peaceful nuclear power need to be overcome, and actions taken to encourage the growth of these industries. While many in the U.S. would like to see the role of nuclear power diminished in favor of natural gas power, this is not going to happen for many years in China. The U.S. should relax restrictions on technology transfers for such items as high capacity power turbines, which can allow China to meet demand.

In summary, then, this thesis advocates an extension of current Clinton administration approaches to China. Engagement is obviously the only real option. The question then becomes what form of engagement. Specifically, the U.S. must be as pragmatic as Beijing is becoming. China is going to get the energy it needs because this is a priority to the government. The U.S. has the power to treat China like a friend and help guide that country's transition to market dependence. Like all friendships, disagreement is inevitable, but this does not have to scuttle the benefits of continued relations. If the U.S. chooses to emphasize the differences between the two countries, and attempts to coerce China into desired behavioral patterns, the chance of success is slim. Nor are such efforts necessary. China is slowly evolving, and further engagement in the world economy can only accelerate this.

China's actions are not necessarily threatening to U.S. interests. The two largest areas of concern are meeting China's future oil needs, and reducing the environmental impact of the country's increasing coal usage. China's current path can address both of these concerns. A developed China is in everyone's interests, as this represents a large

prosperous market. It also means that China will be more likely to transition to modern manufacturing methods and newer power plant designs which will reduce environmental degradation. But changes like these will only occur if China feels secure in relying on world markets for energy, most notably for oil. If the U.S. and other countries see China's growth as threatening, China will likely react by retrenching in traditional methods and by pursuing claims in the South China Sea and other areas.

The U.S. must take the lead in helping China to find its way in the future energy market by helping to increase that country's confidence in market solutions. The true challenge will be in ensuring that policies are in place to continue such cooperation over a change of administration. This is where the Clinton administration must strive to build bipartisan support for engagement with China to prevent it from becoming a political tool. This would benefit neither party, and the whole world would pay the price.

I. INTRODUCTION

There has been extensive literature in recent years about the rising power of China and what this means for the United States. "China threat" writers cover a wide range of activities in China and attempt to show how the U.S. and China are heading towards conflict. A popular example of this school of thought can be found in Bernstein and Munro's *The Coming Conflict With China.*[1] This book and others show how China is likely to use her growing economic power to influence world affairs in ways that threaten U.S. interests. Numerous other authors have picked up on the power of China's economy and continue this theme. One of the best known of these is Samuel Huntington, who wrote primarily about the threat of Japan's economic might in "Why International Primacy Matters," but developed the theme further to include China in "The Clash of Civilizations."[2]

While all of these works contain some valid points, they are searching for a threat where one doesn't have to exist. Much of the blame for any conflict that occurs between the U.S. and China will rest with America as policies the U.S. government takes in the near future have the power to effect the likelihood of any conflict. This is not to imply

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[1] Richard Bernstein and Ross H. Munro, *The Coming Conflict With China*, First Vintage Edition (New York: Vintage Books, 1998).

[2] Samuel Huntington, "Why International Primacy Matters," in *The Cold War and After: Prospects for Peace*, expanded edition, ed. Sean M. Lynn-Jones and Steven E. Miller (Cambridge, MA: MIT Press), 307-327, and "The Clash of Civilizations?," *Foreign Affairs* 72, no. 3 (Summer 1993): 22-49. This theme was later expanded and released as the book *The Clash of Civilizations and the Remaking of World Order*, (Simon & Shuster, 1996).

that it is America's job to manage world growth, but one aspect of this growth that could lead to conflict is meeting growing energy needs. Most of the industrialized world's energy comes from finite resources.[3] These sources are very important to U.S. interests and, as the Persian Gulf war demonstrated, the U.S. is prepared to go to war to protect them.[4]

China has long been viewed as the last frontier for capitalism with her 1.26 billion "consumers" waiting for modern products. At long last, some of these dreams might be coming true. China is becoming increasingly involved in the world economy, something that most observers see as positive.[5] Where the concern arises is when China's growth and U.S. growth cannot both be sustained due to limited energy sources. This concern

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[3] Finite in this sense primarily means short-term. As Sarah A. Emerson points out in "Resource Plenty: Why Fears of an Oil Crisis are Misinformed," Energy Security Analysis, Inc. (ESAI), Available [Online]: http://www.esai.com/oilcrisi.htm [November 10, 1998], the amount of actual available oil not only expands every year, it does so at a rate that generally exceeds expectations. This means that long-term, opportunities exist for countries to obtain needed energy. Nevertheless, they are finite for practical purposes because to guarantee supply, countries enter into supply agreements upon which they then depend. A disruption in a major supply stream can have very real security implications, despite overall world oil abundance. Further, worldwide reserves are not necessarily collocated with centers of world demand, meaning that international arrangements and trade agreements are necessary to redistribute needed oil. These are subject to disruptions from crises that may initiate in countries not involved in the supply chain. This increases impetus among countries to diversify supplies and find "secure" sources.

[4] The official justification for the U.S. intervention in the war was to answer Iraq's aggression against Kuwaiti sovereignty. While this is a true reason, it could be argued that had Kuwait not been an important source of oil for the U.S., events may have unfolded differently.

[5] There has been much written about the virtues of economic liberalism and interdependence. A good analysis of these schools of thought can be found in Robert Gilpin, "Dependence and Economic Development," *from The Political Economy of International Relations* (Princeton, NJ: Princeton University Press, 1987) in *Classic Readings of International Relations*, eds. Phil Williams, Donald Goldstein, and Jay M. Shafritz (Fort Worth, TX: Harcourt Brace College Publishers, 1994), 440-459. For an analysis of the difficulty in attempting to apply economic interdependence theory to China, see Denny Roy, "Hegemon on the Horizon?," *International Security* 19, no. 1 (Summer 1994): 149-168, specifically 156-160.

has been highlighted in numerous articles, including Yergin, Eklof, and Edwards' "Fueling Asia's Recovery," and Calder's "Asia's Empty Tank."[6]

These articles raise the concept of energy security, which can be generally defined as ensuring that a country has a consistent, uniterruptible, and affordable supply of energy sufficient to meet its national objectives for the foreseeable future. In the case of China, affordability is subordinate to security. Examining the policies China is pursuing to obtain energy supplies will show that price appears to be relatively unimportant to China as it aggressively outbids Western oil companies to obtain oil rights in Central Asia and South America.

Energy Security began to assume some of its current significance in the wake of the oil crisis in the 1970's. The desire among the developed countries to prevent any future oil supply disruptions led to the creation of the International Energy Agency (IEA). At that time, the emphasis was almost exclusively on the security of oil supplies. This has evolved over the last 25 years. As Robert Priddle, Executive Dierector of IEA, stated:

> More recently, energy security has become more widely defined. Security of oil and gas supply remain vital. But sensitivity to the environmental consequences of energy production, transport, and use are today no less an aspect of energy security: insensitivity to legitimate environmental concerns could certainly put at risk that unabated supply of energy on which we rely for economic activity.[7]

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[6] Kent E. Calder, "Asia's Empty Tank," *Foreign Affairs* 75, no. 2 (Mar 1996): 55-69; Daniel Yergin, Dennis Eklof, and Jefferson Edwards, "Fueling Asia's Recovery," *Foreign Affairs* 77, no. 2 (Mar-Apr 1998): 34-50. See also and Mark J. Valencia, "Energy and Insecurity in Asia," *Survival* 39, no. 3 (Autumn 1997): 85-106, and Mamdouh G. Salameh, "China Oil and the Risk of Regional Conflict," *Survival* 37, no. 4 (Winter 1995-96): 133-146.

[7] Robert Priddle, "The World Energy Outlook: Security of Supply in a Liberalised Market," speech delivered to the Handelsblatt Conference on the German Energy Market (January 22, 1997), Available [Online]: http://www.iea.org/new/speeches/priddle/1997/pgermany.htm.

The increasing importance of this concept to the U.S. was highlighted in April 1995 when the Institute for National Strategic Studies of the National Defense University conducted a strategic forum on energy security. In the forum's summary, three recommendations were made, two of which are important here. The number one concern identified was that the "U.S. government needs to pay close attention to long-term prospects for Chinese oil imports" reflecting that country's growing importance. The second recommendation indicated the importance of Persian Gulf oil to U.S. needs in stating that the U.S. must have a robust capability to defend this oil from any threat.[8]

The question that this thesis will examine is whether China's pursuit of energy security will be threatening to U.S. interests, and if so, what actions can the U.S. take to reduce that threat. To begin an examination of energy security in China, this thesis will attempt to ascertain what China's goals or objectives are. This will be accomplished by a review of Chinese historical legacies that are behind the current development drive, which will explain the importance of development to Beijing and demonstrate the tenacity China is likely to display in enabling economic growth. That will then lead to an examination of China's economy to determine if this desire for growth is achievable, and if so, what this means for growing energy needs. That information will highlight the scope of the possible problem of energy security, or if any problem exists. As the size of China's growing demand becomes apparent, this thesis will examine the environmental implications of China's current energy usage, as this is one area of potential conflict in

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[8] Patrick Clawson, "Energy and National Security," Strategic Forum no. 26, INSS, National Defense University, (April 1995), from the NDU web page: http://www.ndu.edu/inss/strforum/ forum26.html.

China's energy future. From that point, an examination of China's current and likely future energy options will reveal how much energy China will have to obtain from beyond its borders. This is where China and the U.S. may find conflicting interests. Once the scope of this possible conflict is determined, some policy recommendations can be made to mitigate or remove any sources of tension.

Once completed, this review will show that China's likely future course will have an increasing impact on U.S. and world interests. The largest area of concern will be China's aggressive pursuit of world oil supplies, which could lead to tension. China is almost obsessed with security, to the point that it frequently outbids competitors for oil and gas reserves by 30-50%. These actions frequently resulted in U.S. firms losing out. Secondary to this, but increasingly important, is the tremendous potential environmental impact of China's growing coal usage. Minimizing the problems of both of these will require some judicious U.S. policy choices that may not be politically popular.

II. HISTORICAL LEGACIES

A. THE MIDDLE KINGDOM AND THE "CENTURY OF SHAME"

Much of modern Chinese behavior is strongly influenced by history. China has a long and colorful past with many experiences that effect policy today. A central period in this history has been called the "century of shame" or "century of humiliation." This was a period in which the traditional Chinese view of the world and China's place in that world met head on with competing Western concepts.

Prior to that point, China had occupied a central position in Asia, and to the Chinese, the world. This feeling of centrality goes back to the traditional belief of China as "the Middle Kingdom." In this view, China was the center of the world and was surrounded by "barbarians." The further one was from the center, the less civilized. Traditional Chinese foreign policy placed "states" in a hierarchy with China at the top, and all others subordinate, a position they acknowledged by paying tribute to the emperor.

This idea did not accommodate European views of the world and the concept of the equality of nations. When Western nations began encroachments in Asia, China did not seem concerned, because they were seen as unimportant. The Europeans' main concern was with trade, an occupation that Confucian thought felt was beneath gentlemen.[9] In the past, any outsider who seemed threatening to China was eventually absorbed into Chinese culture, and the Chinese expected this to happen to the Europeans

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[9] As Confucious said, "...[a] gentleman takes as much trouble to discover what is right as lesser men take to discover what will pay." William E. Soothill, (translator), *The Analects of Confucius* (London: Oxford University Press, 1958), IV:16.

as well. This attitude started to change when British traders began bringing opium to China in large quantities to try and make their imperial efforts profitable. Opium began to be seen as a threat to Chinese society, and the Manchu emperor, determined to end this "plague," appointed Lin Ze-Xu as imperial commissioner in Guangzhou to eradicate the opium trade. The British did not passively accept the resulting loss of revenue, and in 1839-1842 they forced China to accept British trade in what has been termed the First Opium War.[10] This began the "century of shame" and over the next hundred years, China's view of the superiority of their culture met reality. Time after time, China would lose in competitions with outside powers and suffer losses of sovereignty and repeated humiliations.[11]

Some subsequent incidents include the *Arrow* War or Second Opium War (1858-1860), a series of "unequal" treaties with many Western powers, further opening to trade, loss of influence in the region as a result of imperialist advances, and the forced granting of extraterritoriality to Europeans in Chinese cities. The resulting weakened Emperor was then faced with internal uprisings from the Taiping and Nien Rebellions, and suffered further humiliation at the hands of a fellow Asian nation, Japan, in the Sino-

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[10] There had been numerous imperial decrees attempting to end China's opium problem in the century leading up to the Opium War. None of these, however were successful, and the appointment of Lin Ze-Xu was the first effective measure. For an overview of the role of Opium in China and the resulting Opium Wars, see Ranbir Vohra, *China's Path to Modernization: A Historical Review from 1800 to the Present*, (Englewood Cliffs, NJ: Prentice-Hall, 1987), 33-38, and 45-51. See also J. Y. Wong, *Deadly Dreams: Opium, Imperialism, and the Arrow War (1858-1860) in China*, (Cambridge, England: Cambridge University Press, 1998).

[11] For an excellent review of Chinese concepts of centrality and the effects of the "century of shame" on these ideas, see William C. Kirby, "Traditions of Centrality, Authority, and Management in Modern China's Foreign Relations," in *Chinese Foreign Policy: Theory and Practice*, ed. Thomas W. Robinson and David Shambaugh, (Great Britain: Oxford University Press, 1995), 13-29.

Japanese War.[12] The scars of this conflict still remain, as this resulted in the ceding of Taiwan in the Treaty of Shimonoseki in 1895. That island remained in Japanese hands until 1945, and once occupied by the KMT in 1949, its control has continued to elude the CCP.

After the war, the authority of the state continued to decline and when the Qing dynasty officially ended in 1911, China decayed into a period of warlordism and civil war. During this period, Sun Yat-sen's Kuomintang (KMT) party formed a Nationalist government, and battled against Mao Zedong's Chinese Communist Party (CCP) for control of China. The KMT was seen by the CCP as a fascist regime that was "almost more foreign than Chinese and inherently traitorous."[13] The KMT was unable to either quell internal disorder, or to withstand the rising tide of Japanese militarism in the 1930's and China suffered another humiliation as the Japanese occupied the country.

Following World War II, the conflict continued as the KMT resumed fighting with Mao's communists for control over China and the right to claim the historical mantle of Chinese greatness. The century of shame came to an end in 1949 with the victory of the Chinese Communist Party and the flight of the Nationalists to Taiwan.

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[12] This is not to imply that all the blame for the Emperor's weakness belongs to the Europeans. Indeed, the Qing Dynasty was already in decline and was having difficulties exercising power before the British arrived. This outside threat merely accelerated the decline.

[13] Kirby, 13.

B. THE COMMUNIST ERA

Mao Zedong rose to power and proclaimed an end to the century of shame by saying that at last, China had "stood up" to the West. The CCP was billed as the saviors of Chinese history who delivered the country from the position of "semi-colony." Mao claimed that China had always been a great nation that had fallen behind "entirely due to oppression and exploitation by foreign imperialism and domestic reactionary governments."[14] In a drive to right this "injustice" the CCP became synonymous with self-reliance and the avoidance of any future Western influence and humiliation. Mao took self-reliance to the extreme with disastrous campaigns like the Great Leap Forward and the Cultural Revolution.[15] The result was that China saw itself falling further behind, and fear of humiliation increased rather than lessened.

This set the stage for the rise of Deng Xiaoping who, being more pragmatic than Mao, recognized the technical superiority of Western nations and decided to use their knowledge to aid China. This was essentially a reincarnation of the traditional *ti yong* philosophy of using western learning "for use" and Chinese experience for the "base" or essence.[16] This is not a new idea, as this was the goal behind the self-strengthening

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[14] Mao Zedong, *Selected Works*, vol v (Beijing: Foreign Language Press, 1977), 22, as quoted in Kirby, 13.

[15] For a detailed accounting of the Great Leap Forward, see Roderick MacFarquhar, *The Origins of the Cultural Revolution, vol. 2: The Great Leap Forward 1958-1960*, (Great Britain: Columbia University Press, 1983). An overview of the Cultural Revolution can be found in Maurice Meisner, *Mao's China and After: A History of the People's Republic* (New York: The Free Press, 1977), 309-434.

[16] Bruce Cummings, "The World Shakes China," *The National Interest*, no. 43 (Spring 1996): 34.

movement of the nineteenth century, which had been intended to fend off the original Western encroachments. It is likely that only after the depths of the century of shame provided a break with rigid Confucian thought, could China successfully apply these ideas.

C. MODERN POLITICAL OBJECTIVES

Today, the CCP has drifted from devout emphasis on ideology and has clung to the success of China's economy as justification for many policies. Many principles have been sacrificed to advance China's position in the world, but the underlying current has been to avoid outside dominance over China and to attempt to restore China's greatness. This is logical for a party that justifies its monopolization of power as being the "party that led China out of the 'century of shame'."[17]

One principle that remains, is the importance of sovereignty to the Chinese leaders. This is an offshoot of the historical experiences described above, and it means that the Chinese are adamant about self-determination and noninterference in what they see as internal affairs. Harold Hinton puts sovereign dignity as second only to security in Beijing's most important external concerns.[18] Many other ideological objectives have lessened in significance, and while the party still espouses to be heading towards an

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[17] Denny Roy, "The Foreign Policy of Great Power China," *Contemporary Southeast Asia* 19, no. 2 (Sept 1997): 123.

[18] Harold C. Hinton, "China as an Asian Power," in Robinson and Shambaugh, 348-372, specifically, 349.

eventual communist society, in practice, the Chinese idea of market socialism is looking very capitalistic.

Actual goals of the government seem to have little to do with the once vaunted communist revolution and are more nationalistic. The over-arching objective other than restoring Chinese greatness, seems to be retaining the CCP's hold on power. Everything today comes down to contributing to China's wealth and power.[19] Hinton sees the main domestic objective as economic development as key to ensuring Chinese greatness and independence.[20] In more specific terms, Nathan and Ross see three goals of Chinese foreign policy, all of which show the "baggage of history."[21]

The first goal is to restore and maintain territorial integrity. This is to undo the last physical vestiges of the century of shame and prevent any future losses of territory. This has become an obsessive goal to the point that no modern Chinese leader could

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19 Andrew J. Nathan and Robert S. Ross, *The Great Wall and the Empty Fortress: China's Search for Security* (New York: W. W. Norton & Company, 1997), 27. This is not to imply that this quest for power can explain everything. This is the approach that many proponents of realist international relations theory would take. For examples of the classical realist school of thought, which traces its roots back to the writings of Hobbes and Machiavelli, see Hans J. Morgenthau, "Six Principles of Political Realism," from *Politics Among Nations: The Struggle for Power and Peace*, 5th ed. (NY: Alfred A. Knopf, 1973), 4-6, 8-12, as reprinted in *Classic Readings of International Relations*, 34-38. The strongest proponent of structural realism is Kenneth Waltz. See "The Origins of War in Neorealist Theory," from *The Journal of Interdisciplinary History* 18, no. 4 (Spring 1988): 39-52, as reprinted in *Classic Readings of International Relations*, 39-47. Also Kenneth Waltz, "The Stability of a Bipolar World," *Daedalus* 93, no. 3 (Summer 1964), 881-887, 899-902, 907-909, as reprinted in *Classic Readings of International Relations, 62-68.* To truly understand Chinese behavior, one must look beyond the limits of any simple theory. China's behavior is affected by many "variables," and one of the most significant that these theories tend to discount is the influence of history. For more on this see Thomas J. Christensen, "Chinese Realpolitik," *Foreign Affairs* 75, no. 5 (Sep-Oct 1996): 36-52, and Nathan and Ross.

20 Hinton, 349.

21 The goals are in *The Great Wall and the Empty Fortress*, 16. The term "baggage of history" is from Denny Roy, 125.

politically survive giving up important territory like Taiwan, Tibet, or islands in the South China Sea.[22] Nathan and Ross's second goal relates to China reclaiming her traditional position as the Middle Kingdom, at least in Asia. This is the goal of preventing any other power from dominating the region. Chinese leaders believe that any power that comes to dominate Asia will likely attempt to dominate China, which as has been shown, will not be allowed. The third goal is to create a favorable environment for economic growth. Only by continuing to grow the Chinese economy, can China catch up with and surpass Western powers, escape the image of the "sickman of Asia," and return to greatness.

Another attempt to determine China's national objective or goals reveals the same historical baggage. This can be found in a speech by Kenneth Lieberthal given in October 1997.[23] Lieberthal gave a brief overview of the century of shame and then tied this in to what he saw as China's goals. This history, according to Lieberthal, shapes Chinese thought in the modern era. Determined to avoid any future "unequal" treatment, Chinese leaders see the opportunity finally presenting itself for China to resume her "rightful" position as a great power. This intent is reflected in the goals he outlined. He listed China's number one objective as a desire for national unity. This means "overcoming the dismemberment of the country that was imposed on them by stronger powers that were

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[22] While, there have been instances of China giving up territory, these instances were in areas not seen as vital, and more importantly, these concessions were made by Mao. It is not widely believed that any modern Chinese leader is secure enough in his position to be able to make such a bold move. For a discussion of this topic and examples of where Mao made territorial concessions, see Nathan and Ross, particularly 115-118.

[23] Kenneth Lieberthal, "China-Domestic Issues, Economic Energy and Security," *Vital Speeches of the Day* 64, no. 3 (Nov 15, 1997): 75-76.

more economically developed over the past century and more."[24] This is essentially Nathan and Ross's goal of maintaining territorial integrity.

The second objective is economic development. This shows that "they recognize that national strength that brought them low was based on more rapid economic development in other countries."[25] This is seen as the key to overcoming the unequal status, and economic growth will play a key role in determining China's actions in the coming years. Again, there is a marked similarity to Nathan and Ross's list. The third national objective, according to Lieberthal, is a desire for social and political stability. These are seen as key to pursuing the first two, and will mean that China is less than receptive to outside pressure to adjust its handling of internal dissent. This is a manifestation of the Chinese saying "*nei luan wai huan,*" which means "disorder within, danger without."[26] While many people may dispute these rather arbitrary labelings of China's unspoken intent, the similarity is enlightening, and the source of Lieberthal's list is a key sign of U.S. policy direction. This speech was delivered at the White House as part of the Clinton Administration's effort to help convince the American people of the importance of engagement with China.

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[24] Ibid., 76.

[25] Ibid.

[26] Denny Roy, 123.

D. IMPLICATIONS FOR ENERGY

Returning to the definition of energy security given in Chapter 1— ensuring that a country has a consistent, uniterruptible supply of energy sufficient to meet its national objectives for the foreseeable future—one can now apply this to China. This chapter's focus has been on attempting to assess the last part of that definition—China's national goals or objectives. The important part for this discussion is the centrality of economic growth and development in all assessments.

China is determined to prevent returning to a weakened position, and only by becoming more developed does it see this as unavoidable. This will lead to a tenacity and determination in pursuit of growth that is reminiscent of Meiji Japan.[27] China's leaders will go to great lengths to continue on their current path. Not only China's greatness but their regime's security is at stake. A challenge with this course is going to be guaranteeing sufficient energy sources to meet rapidly growing needs. The desire to avoid outside influence and ties that could be cut by foreign powers that want to weaken China, would make a dependence on indigenous energy sources the preferred option. This, however, is simply not possible, due to a variety of factors that will be examined in subsequent chapters.

Short of energy autarky, China will be looking beyond its borders for energy in ever increasing amounts. The security aspect of supplies will loom large in most

[27] This is not meant to ascribe any of Japan's past atrocities as being part of any future Chinese plans, only that there are similarities in the way modern China and Meiji Japan chose to answer outside technical superiority.

decisions and lead China to diversify supplies to avoid excess dependence on any one source. When selecting options, the idea that other sources could be cut by Western powers who begin to fear China's growth means that the cost of energy sources will be of secondary importance to their security.

Another aspect of energy choices open to China is the impact of various options on the environment. There is an increasing awareness of the international implications of some countries' domestic development policies. The size of China's growing economy makes this area of grave importance. China's dominant secure energy source is the country's vast indigenous coal reserves. The importance of security to China means that as other energy sources begin to appear less secure, coal will play an increasingly important role. The increased environmental degradation that would likely follow such a scenario makes this an international concern. This is another reason why China's energy needs must be acknowledged, and the U.S. and other developed countries must aid China in finding solutions with minimal negative implications.

As China pursues solutions to her energy needs, the U.S. must view the situation objectively and not treat every Chinese decision as a threat directed at the United States. The Chinese are going to be tenacious in pursuit of economic growth and obtaining energy reserves scattered throughout the globe, including in many countries the U.S. would like to politically isolate, such as Iran and Iraq. China does not share the U.S. agenda with these countries, and based on historical experience, has a strong concept of sovereignty and noninterference in internal affairs that cannot accommodate U.S. style measures against these "rogue" nations. This does not mean that China will intentionally

ignore U.S. interests in these areas, only that China will not rule out dealing with these nations if it fits Chinese needs. The U.S. must be careful as China enters traditionally U.S. influenced regions in search of energy. If China is made to feel unwelcome, it will see fears of a Western conspiracy confirmed. This will not cause them to completely turn inward and ignore the world again. Rather, they will look elsewhere to obtain needed energy, probably from sources the U.S. does not like, with more determination than before, and with less concern for U.S. desires, or environmental impact.

III. CHINA'S ECONOMY AND GROWING ENERGY NEEDS

A. DENG XIAOPING'S REFORMS

By the early 1970's, many Chinese leaders were beginning to see the devastating toll that radical self-reliance was taking on their economy. It was becoming clear to all but the most extreme ideologues, that despite China's best efforts, the country was falling even further behind the rest of the world. Fear of the Soviet Union's military might enabled those in favor of opening to the outside world to persuade Mao that a *rapprochement* with the U.S. would be beneficial. This eventually led to the creation of a strategic triangle with the U.S., the USSR, and China. This arrangement served all three countries in a variety of ways, and in China, it appeared to be a resurrection of the age-old concept of using barbarians to control barbarians. The difference this time around, was the success of the policy.

Throughout the 1970's, as relations with the U.S. improved, the fear of imminent invasion from the north lessened, allowing more attention to be focused on economic concerns. Mao's credibility had been severely weakened by the Cultural Revolution, which opened the door for a possible departure from some of his policies. After his death in 1976, there was much debate among potential leaders as to what course to pursue. Eventually, Deng Xiaoping rose to the top and initiated the "Four Modernizations." The four areas that were seen in drastic need of development were agriculture, industry,

national defense, and technology.[28] This led to major changes in economic policy, which encouraged the formation of rural enterprises and private business, liberalized foreign trade and investments, relaxed state control over *some* prices and encouraged increases in industrial production.[29]

B. SUSTAINABILITY AND THE IMPACT OF THE ASIAN FINANCIAL CRISIS

On the whole, these reforms have been spectacularly successful, with overall growth in China's economy averaging 9.8% a year since 1979, the fastest growth in the world, and 6.5% faster than the world average.[30] This is compared to annual growth in China of 6% before 1978.[31] Also in this period, per capita GDP rose from 397 Yuan to 6,079 Yuan. As the Chinese view it, "over the past 20 years, China's overall national strength has been...enhanced, people's living standards have been notably improved, and all social undertakings have been notably advanced."[32] Aside from domestic benefits, the

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[28] See R. Baum (ed.), *China's Four Modernisations: the New Technological Revolution* (Boulder, CO: Westview Press, 1980).

[29] The "some" is significant, as price controls were not touched in the energy sector, with effects that will be seen. For a review of specific policy changes, see Barry Naughton, "The Foreign Policy Implications of China's Economic Development Strategy," in Robinson and Shambaugh, 47-69, specifically 50-51.

[30] Chen Xin, "Economic Review: PRC Improves International Standing," (Beijing) *Xinhua* (1131 GMT, September 30, 1998), FBIS Document ID FTS 199809300000488.

[31] Zuliu Hu and Mohsin S. Khan, "Why is China Growing so Fast?," *Economic Issues* 8, International Monetary Fund (1997).

[32] Xiao Bui, "Reform Improves National Strength, Living Standards," (Beijing) *Zhongguo Xinwen She* in Chinese (0927 GMT, September 22, 1998), FBIS Document ID FTS 19980924000233.

Chinese also feel that closer links with the global economy have greatly improved the nation's "international standing."[33]

China's leaders emphasize the benefits for the whole world of continuing this growth. President Jiang Zemin believes that "a developed China will represent a strengthened force for peace" [34] and he is committed to continuing the current growth. In April of this year, China's Assistant Foreign Minister Chen Jian outlined the lengths to which his country will go to continue an 8% growth rate into the foreseeable future. These include offering trade credits and barter terms to ASEAN (the Association of Southeast Asian Nations) countries to bypass their currency exchange difficulties. He also asserted China's intention to "maintain the exchange rate of the renminbi at any cost" to ensure China does not catch the current "Asian flu." "China's ambitious plans seem to reveal a boundless self-confidence" and reflect a determination to continue the current economic growth.[35]

But is this growth sustainable? Can China's economy continue to expand at the current rate? This is a topic of much speculation in recent years. The size of China's economy makes this is an important question. By 1996, China had the seventh largest Gross National Product (GNP) in the world at $906 billion (U.S.). In 1997, China ranked ninth in exports with $182 billion, and eleventh in imports with $142 billion.

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[33] Chen Xin.

[34] From a speech given in Kuala Lumpur in November, 1994, as quoted in Bill Tarrant, "Developed China Good for Regional Peace—Jiang," *the Reuters Asia-Pacific Business Report* (November 11, 1994).

[35] Global Intelligence Update, *Stratfor Systems, Inc.* (April 21, 1998), Available [Online]: http://www.stratfor.com.

Additionally, China has the world's second largest foreign exchange reserves (behind Japan), and is the second largest recipient of foreign investment (behind the U.S.).[36] At least until the end of last year, China appeared to be the latest in a long line of Asian "miracle" economies.

Paul Krugman was one of the first economists to analyze the recent rapid Asian growth to determine its roots. Writing in *Foreign Affairs* in 1994, he presented his findings that the Asian growth in all but Japan had been based on largely unsustainable growth in factor input.[37] For this type of growth to continue, there would have to be corresponding increases in efficiency and productivity of the growing economies. Eventually, he said, these countries would reach the finite limit of how many resources they could throw into their economy and still see results as they reached the point of diminishing returns. This would indicate that the Chinese ambitions are unrealistic and destined to meet with failure.

However, Krugman admitted that the Chinese economy was difficult to assess due to its closed nature and different systems of recording progress. A later study by the International Monetary Fund took Krugman's methodology and conducted further research in China.[38] After finding alternative measures of the economy and compensating for unknowns, this study found that China was indeed experiencing rapid and continuous growth in total factor productivity as part of its economic miracle. This

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[36] Martin Wolf, "Asian Crisis: China's Temptation," *The (London) Financial Times* (June 30, 1998).

[37] Paul Krugman, "The Myth of Asia's Miracle," *Foreign Affairs* 73, no. 6 (Nov-Dec 1994).

[38] Zuliu Hu and Mohsin Khan.

source of growth could be sustained indefinitely, meaning China's leaders are on a viable path, barring any obstacles.

The most obvious possible obstacle is the recent Asian financial crisis. Will the effects of this crisis eventually spread to China? So far, the answer seems to be no. China appears to have successfully avoided the rising tide, and when most Asian economies crashed in late 1997, the Chinese economy continued on its previous course, registering 8.8% growth for the year. [39] It has, however, felt the effects of its neighbors' devastated economies in the form of drastically decreased demand for Chinese products in Asia. This drop has slowed China's planned growth to a 7% annual rate for the first half of 1998. While this is still quite respectable growth, especially when most Asian countries are experiencing negative growth, it is short of the 8% goal that Chinese leaders have presented as the minimum necessary to help avoid massive increases in unemployment.[40] Add to this the possible impact recent massive flooding in China could have on domestic demand, and the 8% goal seems unrealistic, despite all of the invested rhetoric.

Further, China's economy does have some structural problems that are quite similar to those of the collapsed Asian economies. In his new book *China's Unfinished Economic Revolution*, Nicholas Lardy points out three specific problems in China that are not viable over the long term. "First, state-owned enterprises are becoming ever more

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[39] "China's Economy Presses Ahead in 1997," *Asia Pulse* (December 31, 1997). This and all subsequent *Asia Pulse* articles are available [Online]: http://www.asiapulse.com.

[40] "China: Slowing Economy," *'In Perspective'-The Oxford Analytica Weekly Column* (July 8, 1998).

indebted, particularly to banks....Second, state-owned banks and other financial institutions are extending loans at what appears to be a pace that will not be economically sustainable," and "third, government revenues declined by two-thirds relative to output between 1978 and 1995."[41] The over-extension of credit and resulting high percentage of nonperforming loans in Chinese banks is pointed out by numerous analysts.[42] This is also recognized by China's leaders as a problem that must be corrected, as evidenced by a recent discussion in the Chinese media.[43]

A further burden that China must address is the problem of reforming state owned enterprises (SOE's) without completely overloading the country's ability to absorb workers. One of the largest problems in this process will be the creation of some sort of social safety net to replace the welfare function of the SOE's. This challenge is explored by Neil Hughes in "Smashing the Iron Rice Bowl."[44]

Despite these difficulties, China is not necessarily heading for financial collapse. Most of the analysts cited above see this as unlikely. The largest cushion between China and a financial collapse is the nonconvertability of the Yuan for capital account

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[41] Nicholas Lardy, *China's Unfinished Economic Revolution* (Washington, D.C.: Brookings Institute Press, 1998), 4-5.

[42] For some examples, see Gerald Segal, "Economic Crisis in China as Reform Effort Stalls," *International Herald Tribune* (Paris, September 28, 1998); Martin Wolf, "Asian Crisis: China's Temptation"; Nicholas Lardy, "China and the Asian Contagion," *Foreign Affairs* 77, no. 4 (Jul-Aug 1998): 78-88; James Harding and James Kynge, "Zhu Rongji: Deng's No-Nonsense Disciple," *The (London) Financial Times,* (March 18, 1998).

[43] Liu Shiba, "Preventing Financial Crisis and Revitalizing East Asian Economy," (Beijing) *Guangming Ribao* in Chinese (September 11, 1998), FBIS Document ID FTS 19980924001655.

[44] Neil C. Hughes, "Smashing the Iron Rice Bowl," Foreign Affairs 77, no. 4 (Jul-Aug 1998): 67-77.

transactions. While many western nations see this as a barrier to business in China, it has served as a shock absorber in the recent crisis and prevented speculators from undermining China's currency. Additionally, unlike many other Asian countries, China has a long term trade surplus and is not dependent on foreign capital inflows to finance a trade deficit.[45]

While these attributes of China's economy may help inoculate it against the current "Asian flu," Beijing still needs to address the problems mentioned above. Especially if China enters the World Trade Organization (WTO) and further opens its markets, the country may not be able to continue sheltering state-owned enterprises and banks. Lardy's *Unfinished Revolution* provides a detailed accounting of steps that can be taken to improve Chinas long-term financial stability. Like most analysts, Lardy is optimistic that China's economy is essentially sound and will continue to grow into the next century.

C. AGGREGATE ENERGY DEMAND AND PREDICTIONS FOR THE FUTURE

As China continues growing, a major challenge for Beijing will be obtaining sufficient energy to fuel the rapidly expanding economy. These energy needs are substantial today, and will be more so over time. The determination that China's leaders are likely to show towards enabling growth means that they will go to great lengths to

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[45] While parts of these explanations can be found in many of the articles cited above, a succinct listing can be found in Nicholas Lardy, "China and the Asian Contagion."

ensure that the development drive doesn't stall due to energy shortages. As a recent *Guoji Shangbao* article summarized the situation, China's "energy development strategy is an important constituent element of the national economic development strategy," and "guaranteeing a supply of energy is the core issue of the energy development strategy."[46] An examination of China's current energy needs, as well as projected supply and demand, will highlight the scope of the challenge facing Beijing.

In 1995, China's total primary energy consumption was approximately 36 quadrillion Btu. This was the second highest in the world behind the U.S. at 88 quadrillion Btu.[47] China was self sufficient in energy until the 1990's when the situation began to change. In 1993, the country became a net importer of petroleum due to a reliance on imports for a variety of refined products. In 1995, China became a net importer of crude oil and overall energy. This is due primarily to the rapid economic growth of the country. Indigenous energy supplies have continued to grow, but are no longer able to keep pace with demand. The specific situation for each source of energy will be examined in subsequent chapters. At this point, aggregates will be sufficient to highlight energy trends.

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46 "Key Issues of Energy Development Strategy," (Beijing) *Guoji Shangbao* in Chinese (July 14, 1998): 6, FBIS Document ID FTS 19980925001692.

47 For consistency, except where noted, all statistics concerning energy in China will come from U.S. Department of Energy sources, principally the Energy Information Administration (EIA). Most statistics used are available on line at http://www.eia.doe.gov. A variety of units will be used as different energy sources use different scales. Conversion factors are provided in the Logan et al, A-13, and at the IEA web page, http://www.iea.org/stats/files/conen.htm.

Forecasting future energy import demand will be the key to determining if China's pursuit of energy security is a threat to U.S. interests. This task comprises two separate requirements. The first is projecting the future growth of China's economy and examining any likely structural changes to determine future energy demand. That will be the focus of the remainder of this chapter. The second part of the puzzle will be an examination of China's indigenous energy sources and a review of options for the future to determine how much of the demand can only be met through imports. That will be done in subsequent chapters. Following that, a review of current and future import options available to China will determine whether China's needs can be met without conflict.

As discussed earlier, it appears that China's economy is essentially sound and will likely continue growing. The challenge now becomes determining the extent of future growth. There have been numerous attempts to do this over the last twenty years, and most have woefully underestimated the potential of China's economy.[48] A partial explanation for this is that China is managing to increase efficiency as it develops.[49] This has made predictions difficult, as China keeps "squeezing" more and more output from

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[48] One of the biggest challenges in predicting China's economic future has been the difficulty of obtaining accurate and predictable data. This affected the ability of Krugman's study to fully assess China. As the IMF study described the situation, "this difficulty in obtaining meaningful data means that "figures for Chinese economic growth...vary depending on how an analyst decides to account for them." Zuliu Hu and Mohsin Khan, 2. For more on this challenge, see Lardy, *China's Unfinished Economic Revolution*, 9-10.

[49] This will be explored in more depth in Chapter IV. This chapter will simply rely on predictions of China's growth that have been reasonably accurate.

every unit of input. The result is growth that keeps exceeding predictions and energy demand that is growing, but slower than GDP.

Of the numerous efforts to predict China's growth in the last decade, one of the most successful was done by RAND. In *MAGIC: Models of Aggregate Growth in China*,[50] Donald Henry constructed three different models to make predictions about China's economy, and considered a wide range of variables to try and account for every conceivable growth strategy open to China. The scenario that has proven the most accurate thus far, was a "high productivity, high savings" combination run through the civil-military interactions model. This model is a good choice as it incorporates the military sector, unlike many other models. The PLA in China plays a large role in the economy, and excluding its effects would capture only an incomplete picture of the economy.

The result of this scenario predicts an annual GDP growth rate of slightly more than 7% through 2010. Based on recent performance, this prediction seems possible. The more conservative estimates in the RAND study expect growth in the 5-6% range. For the purposes of computing energy demand in this thesis, the lower estimate of 5% will be used as a low growth scenario, and 10% (the recent average of 9.8% rounded up) will be used for the high growth scenario.

Based on China's displayed energy usage patterns, demand for energy should be expected to grow at a rate slightly less than these two figures. Some predictions of likely

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[50] Donald Putnam Henry, *MAGIC: Models of Aggregate Growth in China (Santa Monica: RAND, 1991).*

energy growth can be found in Table 1. This table gives a picture of predicted growth in China's energy demand from 3 different sources. The World Bank projects approximately 6.5% annual growth through 2005 with no projections beyond that. The International Energy Agency (IEA) projects 4.4% annual growth through 2010. The U.S. Department of Energy's (DOE) internal study provides two estimates.[51] The first is the business-as-usual (BAU) scenario that applies projected economic growth to current energy supply patterns, anticipating no major structural changes in the industry. This scenario predicts an increasing rate of growth from 5.3% through 2000, rising to 6.6% for 2011-2015. As an alternative view, the energy efficient (EE) scenario assumes that China takes the type of conservation actions stated in the ninth five-year plan, and takes advantage of some existing technology to reduce wastage. This scenario still predicts increasing growth, though less than the BAU scenario. These projections are for 5.1% growth through 2000, and 5.8% for 2011-2015. A more recent study done by the EIA predicts 5.4% energy growth through 2020.[52]

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[51] This study was conducted jointly by the Los Alamos National Laboratory, which completed information for China's energy supplies, and the Pacific National Laboratory, which completed all information on energy demands. It was published as E. Ian McCreary et al, "China's Energy: A Forecast to 2015," U.S. Department of Energy, Office of Energy Intelligence, publication LA-UR-96-2972 (September 1996): III-4.

[52] *International Energy Outlook 1998: With Projections through 2020*, U.S. Energy Information Agency (April 20, 1998), Available [Online]: http://www.eia.doe.gov/oiaf/ieo98/home.html.

Years	1994-2000	2001-2005	2006-2010	2011-2015	Demand in 2005
World Bank	6.5	6.5	N/A	N/A	1,267 Mtoe[53]
IEA	4.4	4.4	4.4	N/A	987 Mtoe
BAU	5.3	6.0	6.4	6.6	1,136 Mtoe
EE	5.1	5.6	5.7	5.8	1,103 Mtoe

Table 1. Projected Energy Demand Percentage Growth Rates[54]

For computations in this thesis, the low growth scenario will use 4% growth in energy demand (the IEA prediction rounded down) and the high growth scenario will use 8% (a figure less than expected economic growth, yet higher than any of the estimates in the table. This will provide two extreme values to determine likely possibilities. Further, this thesis will follow a business as usual approach similar to the DOE's. In this thesis, this means that the basic distribution of China's energy usage among different fuels will remain essentially static. Using the two scenarios of high and low growth allows for energy efficiency measures to be implemented without dramatically altering either extreme. Any changes in this area would simply slide the total demand more towards the low growth extreme. One difference in these scenarios that will have implications for security is the possibility that the percentage each type of fuel occupies in current usage might change. One likely version of this possibility will be discussed later in this chapter. While this could have significant impact on the scope of demand for some fuels, by

[53] Mtoe is Million tons of oil equivalent. The abbreviations toe and tce (tons of coal equivalent) are frequently used as a standard comparison of energy levels.

[54] Adapted from McCreary et al.

examining the high and low growth scenarios to see if the pursuit of needed energy could lead to conflict, it will then be easy to explore variations in closing chapters.

D. CURRENT ENERGY USAGE

China's Total Primary Energy Supply (TPES) in 1996 was 1097 Mtoe. Total Commercial Energy Consumption (TCEC) was 838.9 Mtoe, and came from the various fuels as indicated in Figure 1.[55] Of this total, 325 Mtoe, or 38.7%, went to electricity generation. The remainder was distributed among the various end-use sectors as shown in Figure 2., all of which are continuing to grow as part of ongoing development plans. McCreary et al predicts that the overall distribution will change only slightly, with industry's share decreasing. The electricity sector is very important to China's development plans as this provides energy for many other enterprises. Additionally, increasing electrification is a key social goal as approximately 100 million people live without electricity.[56] Further, due to the variety of options available in this sector, later

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[55] The TPES figure is from the International Energy Agency (IEA), "Key Energy Statistics for China," Available from the IEA web page [Online]: http://www.iea.org/stats/files/selstats/keyindic/nmc/ china.html. The breakdown by fuel is created from data in Jeffrey Logan et al, *China's Electric Power Options: An Analysis of Economic and Environmental Costs*, Advanced International Studies Unit, Pacific Northwest National Laboratory Report Number PNWD-2433 (June 1998). Available [Online]: http://www.pnl.gov/ China/chinapwr.pdf, 1. TCEC reflects only commercial energy supply, while the TPES inculdes rural supplies of noncommercial sources, such as small applications of wind and solar power, and the extensive use of biomass. The total measure of these types of sources amounts to over one quarter of the TPES. These sources are not applicable to the commercial energy market, and are limited to specific applications that will be discussed in Chapter VI. Most comparisons in this thesis will use TCEC.

[56] Estimates of this number vary widely from a low of 70 million in Buczek, "Fueling China's Growth," to a high of 200 million in Elizabeth Economy, "The Environment and Development in the Asia Pacific-Region," in *Fires Across the Waters: Transnational Problems in Asia*, ed. James Shinn (New York: Brookings Institute Press, 1998), 49. The official Chinese estimate is 72 million. 100 million is a reasonable middle ground that is chosen by numerous other sources, including *International Energy Outlook 1998.*

chapters, which examine various energy options, will focus primarily on applications that are applicable to the electricity sector.[57]

In 1996, China's total electrical generating capacity was 232 GW. In 1995, 76% of this came from coal fired plants, 19% from hydroelectric power, 4% from oil and gas, 1% from nuclear, and 1% from other renewables. These percentages are expected to evolve slightly as China attempts to raise capacity. Demand for electricity in the 1990's has outstripped overall energy growth and GDP growth by increasing at a 10% annual rate.[58] This increase is due to a number of factors, including an increase in electric machinery in agriculture and manufacturing, the evolving importance of high electricity intensity industries such as petrochemicals and construction materials, and an increasing standard of living that is demanding more residential electricity.

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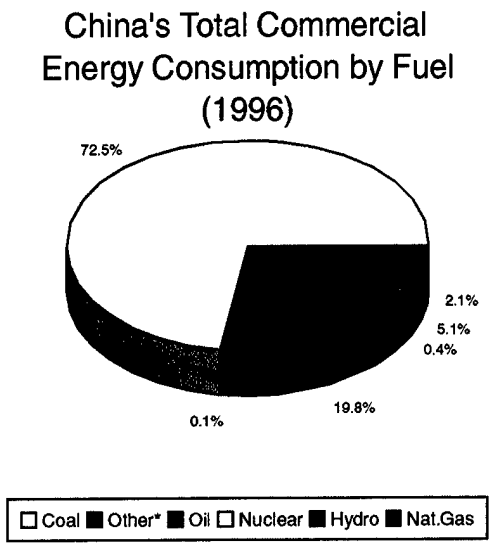
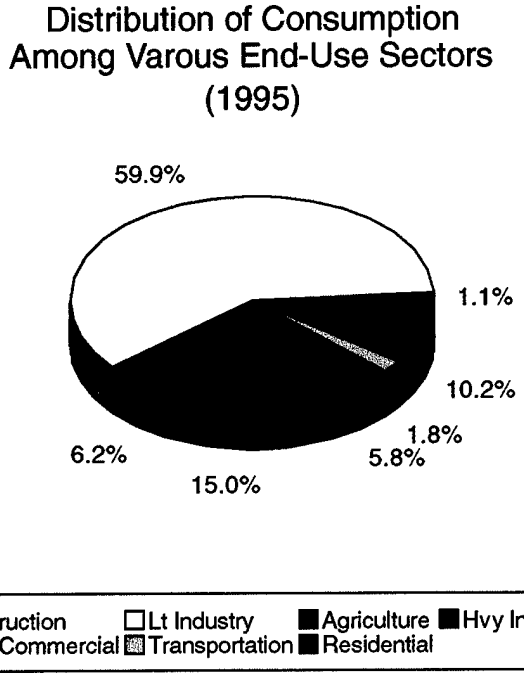
[57] The single largest energy using sector in China is actually the industrial sector, but this is a very diverse grouping of many types of enterprises. Exploring all of the options available for meeting energy needs in every possible manufacturing arena would be beyond the scope of this thesis. The electrical sector is the largest user of energy that represents a relatively homogeneous grouping, where the end product is indistinguishable among suppliers. Therefore, various options for filling needs are essentially interchangeable, which makes for good comparisons. This will permit a relatively thorough review of the options open to a single large user of China's energy.

[58] Logan et al, 26.



Source: Logan et al, 1. * Includes Renewables

Figure 1. China's Energy Consumption



Source: Logan et al, 8.

Figure 2. Sectoral Distribution of Energy Use in China

The Advanced International Studies Unit (AISU) of the Pacific Northwest National Laboratory predicts that these factors will be somewhat mitigated in coming years by the development of advanced technologies, which will reduce electricity intensity in many industries. As a result, AISU predicts annual electricity demand will grow, but at a decreasing rate, starting at 6.8% for 1996-2000, declining to 4.5% by 2016-2020. This is comfortably between the high and low growth extremes, therefore, those numbers—though derived from total energy demand—will be applied to electricity demand to evaluate various options.

Table 2. applies the low and high growth rates to the 1996 electrical generating capacity of 232 GW and derives capacity for each year through 2010 that will be needed to meet demand.

Year	Low Growth (4%)	High Growth (8%)
1997	241.28	250.56
1998	250.93	270.60
1999	260.97	292.25
2000	271.41	315.63
2001	282.27	340.88
2002	293.56	368.15
2003	305.30	397.60
2004	317.51	429.41
2005	330.21	463.76
2006	343.42	500.86
2007	357.16	540.93
2008	371.45	584.20
2009	386.31	630.94
2010	401.76	681.42

Table 2. Required Growth in Electricity Generation Capacity (GW)

The ninth five-year plan sets ambitious goals of 300,000 MW by 2000, and 540,000 by 2010.[59] These goals, if met, will exceed the low growth requirements for 2000 by 29 GW or 10.5%, and the requirements for 2010 by 138 GW or 34%. However, This rate of development would fall short of needed capacity under the high growth scenario by 16 GW or 5% in 2000, and by 141 GW or 21%. Hydropower, nuclear, and natural gas will likely increase their shares slightly, but coal will remain dominant. The specific role of each of these will be discussed in subsequent chapters, as well as the potential of each to absorb more capacity if the high growth scenario occurs. In those discussions, the impact of growing demand will be assessed with reference to indigenous production capabilities to determine import requirements.

E. THE GROWING IMPORTANCE OF OIL

As mentioned, the business as usual approach assumes that the distribution of the various components of China's TCEC will change little in the coming years. This allows for simple calculations and predictions. Further, this is the approach taken by most analysts, therefore, it is a sensible starting point. However, this distribution is not necessarily going to stay the same. One of the most likely modifications is the possibility of oil taking on a more important role.

This would simply mean that as China develops, its energy picture will come to look more like most other developed countries. Many sectors in China have artificially

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[59] These numbers are compared to current U.S. capacity of 706,000 MW. (a Megawatt is a measure of instantaneous capacity and does not reflect actual usage) Buczek, 8.

low oil consumption today due to a shortage of supply either resulting from either government rationing or transportation inadequacies. According to the IEA, "there will undoubtedly be an increase in residential and transport sector energy demand when supply problems are alleviated and energy becomes available."[60] Increases in oil and gas usage are likely to result as China's transportation sector grows rapidly, trains are upgraded to new diesel engines, China's consumers get used to automobiles, and the residential sector gains increased access to modern heating and cooking sources.

Some indications of this trend can already be seen. One example is the growth of China's automotive industry, which produced 13.2 million motor vehicles in 1996, compared to a mere 560,000 in 1988.[61] The total number of motor vehicles registered in China in 1995 rose to 10.4 million, from only 1.2 million in 1975.[62] Of this number, over 60% is due to commercial trucks and buses, over twice the percentage in the United States. As private cars—and the fuel to run them—become more available in China, it is likely that the number of cars will raise dramatically, further increasing oil demand. In the residential sector, over 80% of today's rural energy needs in China are filled by noncommercial fuel sources like biomass. This is not factored into the above totals. As

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[60] *The World Energy Outlook 1994*, IEA, Executive Summary, 4, Available [Online]: http://www.iea.org/iea/goals/files/eadweo94.htm.

[61] William Spodak, "Power Struggle," *The China Business Review* 25, no. 2 (March 1998): 25.

[62] This is a combined total of automobile registrations, which were 4.179 million and .351 million in 1995 and 1975 respectively, and truck and bus registrations of 6.221 million and .811 million in the same years. Stacy C. Davis et al, *Transportation Energy Data Book: Edition 17*, Center for Transportation Analysis, Oak Ridge National Laboratory Publication ORNL-6919 (June 1998), Available [Online]: http://www-cta.ornl.gov/data/tedb17/tedb17.html, 1-2, 1-3.

the society develops further, more of the rural areas could switch to conventional sources, further increasing the importance of oil and gas in China's future.

All of these increases in demand would mean that while oil and gas may likely increase their share of the TCEC, their relative contributions to electrification will likely fall. The limited supplies of these fuels available will make them too valuable to use in areas where other fuels can meet needs. For electrification, this means that whatever demand cannot be met by hydropower, nuclear, and commercial renewables, will likely be absorbed by coal. Therefore, the increasing importance of oil and gas in China will also lead indirectly to greater usage of coal, with all of its environmental implications.

The EIA's conclusions in McCreary et al suggest that, while China will turn to the world market for increasing amounts of oil, the quantities demanded will not likely impact the world price structure. If these quantities dramatically increase, this could change. China's demand, coupled with any resurgence of 1970's style oil supplier cooperation in raising prices could have a huge impact on U.S. energy security. While this is not necessarily going to occur, it is a scenario that needs further exploration. The significance that an increased dependence on oil could have on world supplies will be examined after the role of oil is reviewed. For now, it is beneficial to just recognize that this is one possibility that could change many predictions, as oil is the most politically important energy source to most countries.

IV. CHINA, ENERGY, AND THE ENVIRONMENT

A. THE ENVIRONMENT-SECURITY LINKAGE

The quote by Robert Priddle, Executive Director of the IEA, in the introduction (page 3) highlights the important role that environmental impact is beginning to assume in world energy policies. This theme is increasingly being heard from groups like the IEA— an organization created to help guarantee the security of the industrialized world's oil supplies. Priddle said in a different speech that "environment questions are now one of the driving forces of energy policy."[63] He went on to state that "ensuring that energy exploitation and use is environmentally acceptable is, indeed, now an important aspect of long-term security of supply."[64]

This increasing connection between security and the environment is reflected in the U.S. National Security Strategy, which states "decisions today regarding the environment and natural resources can affect our security for generations."[65] Man's most pronounced impact on the environment comes through energy usage, with the energy sector accounting for approximately three-quarters of the world's carbon dioxide (CO_2)

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[63] Robert Priddle, "Changes in World Energy," Fourth TERI Foundation Day Lecture, New Delhi (December 3, 1996): 5, Available [Online]: http://www.iea.org/new/speeches/priddle/1997/pindia2.htm. [October 10, 1998]

[64] Ibid, 6.

[65] *A National Security Strategy for a New Century*, (Washington, D.C.: The White House, October, 1998)

emissions, one-fifth of its methane, and a "significant quantity" of nitrous oxide.[66] From this perspective, it is clear that choices a country makes in its pursuit of energy security can have impacts beyond its borders. The Clinton Administration's view is that "environmental threats do not heed national borders and can pose long-term dangers to [U.S.] security and well-being."[67]

Specifically pertinent to this analysis, China's future energy choices are of great concern to that country's neighbors and to the United States. China has a significant challenge ahead in meeting its growing energy needs. The scope of likely future Chinese energy usage makes Beijing's energy choices security issues for the entire world. Therefore, this chapter will review the environmental impact of various energy options and possible ways of mitigating that damage. When subsequent chapters examine the specifics of each energy source in China, the environmental aspects of each can be kept in mind to fully assess the implications of any choices the Chinese make.

B. ENERGY AND THE ENVIRONMENT

Environmental pollutants can be classified by a number of means. First, there are two general categories: man-made, and naturally occurring materials. The first of these refers to materials that "are not part of natural environmental cycles and therefore do not

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[66] "Global Climate Change-Science and Solutions: What is the Energy Sector's Role?," A Fossil Energy Issue Review, U.S. Department of Energy, Available [Online]: http://www.fe.doe.gov/issues/globalclimate_energy.html. [October 2, 1998]

[67] *A National Security Strategy for a New Century*, 13.

readily break down when released into the environment."[68] The latter of the two concerns naturally occurring materials, but ones "that appear in much higher concentrations than would normally be the case."[69] These are not inherently harmful, but can be when natural cycles are overloaded. The energy sector emits byproducts in both of these categories. The effects of those products can be grouped into three areas of concern. These are air pollution, water pollution, and toxic hazardous waste disposal.[70] The most pronounced effects, and those that will receive the most attention here, are energy's contributions to air pollution. This is because nearly 90% of the world's energy comes from fossil fuels, and the most serious polluting effect of fossil fuels is the release of various compounds into the air that occurs when they are burned.[71]

1. Air Pollutants from Fossil Fuels

Those compounds released in the burning of fossil fuels are essentially naturally occurring materials, but as mentioned above, they are in vast quantities and are released at such a rapid rate that the ecosystem cannot absorb them. The primary pollutants released are nitrogen oxides (NO_X), sulfur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2), and ozone.[72] Most of these are not inherently harmful, but can be at certain levels.

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[68] Chris C. Park, *Acid Rain: Rhetoric and Reality* (NY: Routledge, 1990), 2.

[69] Ibid.

[70] Paul In-Fei Liu, *Introduction to Energy and the Environment* (NY: Van Nostrand Reinhold, 1993), 1.

[71] Energy Usage Statistic is from *International Energy Outlook 1998.*

[72] Liu, 8.

CO_2 is a naturally occurring byproduct of many processes including breathing, and is essential for plants to use to produce oxygen. However, energy use has raised the levels in the atmosphere well above the ability of the environment to absorb it, and the remainder collects in the atmosphere along with other byproducts of fossil fuel use—principally methane and nitrous oxide—as "greenhouse gases" (GHG). Also released during the combustion of fossil fuels are various amounts of particulate matters, such as coal ash. These impact the environment around their source, and pose a health risk to humans who inhale them.

2. Other Effects of Fossil Fuels

Though this thesis will focus on air pollution, the world's (and particularly China's) extensive use of fossil fuels poses other risks to the environment, by affecting water and land as well. The risks to water include dumping of solid wastes or waste-water from power plants or seepage of acid runoff from mines into rivers and streams, and risks of spills and leaks from petroleum extraction, processing, and shipping operations. In China today, seven major river systems are considered severely polluted.[73] Even if none of these potential problems occurred, many uses of fossil fuels—especially power generation—require vast quantities of water during routine functioning. In China, many fuel sources are located in arid regions, so that when power plants are built at mine sites to minimize transportation, they may impact the available water in those regions.[74]

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[73] Logan et al, 14.

[74] For a discussion of these issues in China, see Vaclav Smil, *China's Environmental Crisis: An Inquiry Into the Limits of National Development* (Armonk, NY: M.E. Sharpe, 1993), 115-116.

The largest impacts of fossil fuels on the land occur in the loss of arable farmland and deforestation.[75] The first of these is particularly significant in China with its vast population to feed. Coal is the biggest offender in this category, contributing to land loss all the way through its usage cycle. Coal mines cause obvious damage to the land, especially surface mines. In China, even underground mines can have a huge impact, as the roofs are frequently caved in to extract ore. Vaclav Smil estimates that mines claim land at the rate of 5,000 ha per year.[76]

The construction of power plants—not just coal-fired—claims even more land. Smil estimates that between 1957 and 1990, this claimed over 60,000 ha. After coal is burned, huge amounts of ash are generated which is then dumped, claiming more land, at the rate of 6,000 ha per year. These and other factors have contributed to the loss of arable farmland in China at the rate of over 1 million ha (Mha) per year from 1957 to 1990. This rate has decreased somewhat in the 1990's but China had only 95.72 Mha of arable farmland in 1988, and must feed a growing population.[77]

Deforestation is also a significant problem in China. Caused largely by sulfur emissions, the rapid loss of forests has accelerated desertification. Its effects are quite

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[75] Many of the other effects that energy usage has on land are byproducts of waste dumping. This is generally seen as contamination of ground water or streams due to hazardous materials leaching though soil or reaching streams through runoff. For a review of U.S. efforts to control these problems, see U.S. Congress, Office of Technology Assessment, *Managing Industrial Solid Wastes From Manufacturing, Mining, Oil and Gas Production, and Utility Coal Combustion,* Background Paper OTA-BP-0-82 (Washington, D.C.: U.S. Government Printing Office, February 1992), Available [Online]: http://www.wws.princeton.edu/~ota/ns20/pubs_n.html.

[76] A ha is a hectare, or 2.47 acres. Estimate in Smil, 112-113.

[77] Ibid, 141.

obvious in southwestern China. One of the more pronounced examples is Sichuan Province. This once lush area now has less than 12% forest cover.[78]

3. Acid Rain

Acid rain is one of the most damaging and widespread effects of fossil fuel pollution. The primary acid gases emitted in energy usage are oxides of sulfur (SO_x) and nitrogen (NO_x). These gases are formed when elemental sulfur and nitrogen in fossil fuels combines with oxygen. The emitted gases react with hydroxyl radicals in the atmosphere to form sulfuric and nitric acid, then they combine with water vapor and fall to the earth as "acid" rain or snow.[79] They can also attach to other particles in the air and fall to earth as "dry deposition," which becomes acidic when it comes into contact with water. This tends to be a relatively localized phenomenon, generally landing between 5 and 25 km from the source. In contrast, acid rain can occur thousands of kilometers from the source, constituting an "invisible export."[80]

Dry deposition generally has the most noticeable effects by causing damage to humans, vegetation, and buildings. In China, these effects are taking their toll through health problems, damage to historic structures, and by threatening the future viability of

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[78] Logan et al, 14.

[79] See Lyuba Zarsky, "Energy and the Environment in Asia Pacific: Regional Cooperation and Market Governance," Draft Paper Presented at the Symposium on the United Nations in the 21st Century, United Nations University, New York (November 14-15, 1997), Available from the Nautilus Institute Web Page at: http:// www.nautilus.org/aprenet/library/regional/Zarsky_energy-envir.html [November 17, 1998].

[80] Park, 3.

prime agricultural land and forests. This is, however, largely confined to Chinese territory and the problem tends to be internalized by China, and its severity downplayed.

4. Greenhouse Gases

Greenhouse gases (GHG) refer to gases emitted that amplify the atmosphere's natural greenhouse effect, and thus contribute to global climate change.[81] While the effects of these gases may be difficult to track, the rising levels of them in the atmosphere is verifiable.[82] The primary GHGs, in order of their contributions, are CO_2, methane, halocarbons, and nitrous oxide.[83] CO_2 is the largest offender, responsible for an estimated 64% of GHG input. 86% of the CO_2 comes from the burning of fossil fuels and another 12% from the burning of biomass. Methane is a much more powerful contributor to the greenhouse effect, but is present in much smaller quantities than CO_2. It still accounts for nearly 20% of the greenhouse effect. It comes from many sources including the refining of oil, where it is routinely vented or flared in many countries, and the burning of biomass. Approximately 10% of the effect is attributable to halocarbons or CFCs, and the remaining 6% is from nitrous oxide.

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[81] For a review of the greenhouse effect, see Kevin Gurney, "Global Warning and the Greenhouse Effect," *Energy and Security*, no.5, Institute for Energy and Environmental Research (March 1998), Available [Online]: http://www.ieer.org.ensec/no-5/globwarm.html. [October 10, 1998]

[82] It is necessary to acknowledge here that many people remain unconvinced that this phenomenon is occurring. The level of climate change predicted is extremely difficult to measure, therefore, scientific certainty is elusive. According to the U.S. DOE, temperatures have risen between 0.5 and 1.1 degrees F since 1860. See "Global Climate Change: Science and Solutions," A Fossil Energy Issue Review, U.S. Department of Energy, Available [Online]: http://www.fe.doe.gov/issues/ globalclimate_intro.html. [October 2, 1998]

[83] Gurney, 2.

Global warming has received more international attention than other environmental issues in recent years due to its truly global character. Acid rain and other damage can be internalized or regionalized, but global warming is not so easy to isolate. The nature of this hazard is such that every nation contributes to every other nation's well-being by its contributions to the global total of GHGs. This has led to attempts to deal with the issue on a global scale. The most comprehensive attempt so far is the Kyoto Protocol to the United Nations Framework Convention on Climate Change.[84] This agreement is the subject of much criticism for its failure to include developing countries—including China.[85] In spite of this shortcoming, Kyoto is an acknowledgement that a problem does exist, and that it will take an international response to limit the damage.

C. POLLUTION WITH CHINESE CHARACTERISTICS[86]

Having seen an overview of air pollution and other effects of fossil fuels use on the environment, a more in depth look at some of the worst environmental problems facing China is warranted. This will highlight the importance of considering the

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[84] The text of the Kyoto Protocol is available [Online]: http://www.cnn.com/SPECIALS/1997/global.warming/stories/treaty/. [October 2, 1998]

[85] For some representative opinions on the Kyoto Protocol, see Patrick J. Michaels, "The Consequences of Kyoto," *Cato Policy Analysis* no. 307, Cato Institute, Available [Online]: http://www.cato.org/pubs/pa-307.html [October 2, 1998]; Stuart Eizenstat, "Stick With Kyoto: A Sound Start on Global Warming," *Foreign Affairs* 77, no. 3 (May-June 1998): 119-121; and Ronald Bailey, "The High Cost of Kyoto," *Chief Executive*, no. 135 (June 1998).

[86] This was the title of a summary of Chinese pollution by Neil C. Hughes, in "Smashing the Iron Rice Bowl."

environment in energy planning, and set the stage for understanding China's energy picture.

The problems that will be reviewed here are energy sector emissions that contribute to the greenhouse effect and to acid rain.[87] China has other air pollution problems, including high particulate and lead emissions, but these are already being substantially addressed. Particulate emissions in China have been largely stabilized. In the power sector, particulate emissions in 1987 totaled 3.9 Mtons. By 1994, the annual total had risen to just 4 Mtons. This is despite an increase in generating capacity of large power plants from 55 GW to 108 GW. The average particulate removal rate over this period rose from 92% to 95.6%.[88] China has applied the existing standard technological solutions to this problem, due to their relatively low cost. Further reductions are unlikely to be attempted due to "financial constraints and [lack of] enforcement of the existing emissions standards."[89]

Lead emissions are a serious health hazard in China. 90% of these come from automobile exhausts. The rising number of cars in China quickly raised the magnitude of this problem in recent years. The proven method for combating these emissions is switching to unleaded gas. Many developing countries resist doing this, due to the

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[87] For simplicity, throughout the remainder of this thesis, the popularized term "acid rain" will be used to refer to all effects of acid gases, including both wet and dry deposition.

[88] Logan et al, 15

[89] Lin Gan, "Energy Development and Environmental Constraints in China," *Energy Policy* 26, no. 2 (February 1998): 119-128, specifically 123.

expense involved in converting their cars, refineries, and other assorted parts of the petroleum supply chain. China has just recently made such a move by announcing that in 1998, eight major cities would switch to unleaded gas and that it would be in use nationwide by the year 2000.[90]

Despite all of these measures, China still faces an enormous problem. The situation is summarized succinctly in Logan et al:

> In almost every major city, oxides of sulfur and nitrogen as well as particulates exceed government standards, often by several hundred percent. Urban air pollution is responsible for millions of deaths and injuries each year in China. Acid rain has damaged from 10 to 40 percent of the land area, and air pollution contributes to over 7 million work-years lost each year to related sickness. Total GDP loss due to environmental pollution exceeds 8 percent.[91]

1. Acid Rain in China

The primary acid gas that will be dealt with here is Sulfur dioxide. Ninety-four percent of all sulfur emissions come from the combustion of coal. China's extensive usage of coal translates directly into heavy sulfur emissions. The largest contribution comes from coal-fired power plants, while the second largest contributor is industrial furnaces. Only a handful of China's power plants are equipped with desulfurization equipment, and almost no industrial facilities are. Only 14 percent of all coal used in

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[90] "The World Oil Market," in *International Energy Outlook 1998*, 17-18.

[91] Logan et al, 13. The estimate of GDP loss due to pollution is from World Bank, *China 2020: China's Environment in the New Century: Clear Water, Blue Skies* (Washington, D.C.: The World Bank, 1997).

China is washed, and most of that is coking coal used in the metallurgical industry.[92] SO_2 emissions have been rising in recent years in direct correlation with the increase in coal-fired power plants. Total emissions in 1994 were 19 Mtons. This number will likely climb dramatically as China struggles to meet electrification goals.

Acid rain is a spreading problem in China. Once an urban phenomenon, it has crept into large rural areas. The hardest hit regions are in south central and southwestern China. In many areas, 80% of precipitation episodes are acidic (ph below 5.0), with frequent occurrences under 3.5, and some as low as 2.8. The problem is also migrating, and is beginning to effect eastern China, and some cities in the north. Direct charges in four provinces during the late 1980's as a result of acid rain have been estimated at roughly $2 billion (U.S.). Damage to forests have been estimated to be $125 million (U.S.) annually.[93] Add to this the lost work hours and health problems mentioned above, and the scope of China's acid rain problem becomes apparent.

The rest of Asia is aware of this problem because they share it. As the National Security Strategy notes, threats like acid rain do not heed borders. Some of the acid gases emitted from China's industries blows east and lands in the oceans, or in Korea and Japan. As shown in Table 3., while the percentage of China's acid deposition that lands in other

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[92] These statistics are from Jonathan E. Sinton, "China's View of Acid Rain in Northeast Asia and Regional Cooperation Strategies for Mitigation," Energy Analysis Program, Lawrence Berkeley National Laboratory, Available from the Center for Global Communications, International University of Japan Web Page at: http://www.glocom.ac.jp/eco/esena/ resource/sinton/AcidRain.html [November 17, 1998], 4. Washing of coal is the simplest method of removing some of the sulfur in coal. It is routinely done in most industrialized countries. The 14% statistic is from Gan, 123.

[93] Sinton, 6.

Asian countries is actually quite small—three percent—it can have a large impact. China's deposition accounts for 35% of the total in North Korea, and 39% in Vietnam. These countries, along with Japan and South Korea are experiencing some of the same effects China is seeing, principally deforestation and reduced crop yields. The acid deposition that falls in the oceans impacts all of the countries in the region by diminishing or destroying fish populations.[94] These reasons make Chinese emissions a problem for all of Asia, if not the world.

Country-To-Country Source-Receptor		
RECEPTOR	% of China's Deposition in Asia	% of Receptor's Total Deposition
China	83	98
Oceans	14	37
North Korea	0.8	35
South Korea	0.4	13
Japan	0.5	17
Vietnam	0.4	39

Table 3. Distribution of China's Acid Deposition[95]

[94] For more on the effects of acid deposition in China and its neighbors, see Zarsky, 4-5; Sinton, 4; and Peter Hayes and Lyuba Zarsky, "Acid Rain in a Regional Context," Paper Presented to Policy Seminar: The Role of Science and Technology in Promoting Sound Development, Science and Technology Institute, UN University, Seoul (June 13-15, 1995): 1-4, Available from the Nautilus Institute Web Page at: http:// www.nautilus.org/aprenet/library/regional/acidrain.html. [November 17, 1998]

[95] From Gregory R. Carmichael and Richard Arndt, "Baseline Assessment of Acid Deposition in Northeast Asia," ESENA (Energy, Security, and Environment in Northeast Asia), the Nautilus Institute, Available [Online]: http://www.nautilus.org/esena /papers/carmichael.html. [November 17, 1998]

Formulating a regional approach to this problem has been difficult, due to the tendency to assess blame for cross-border pollution. China is willing to cooperate in technical research and development to help mitigate acid gas emissions, but steers clear of accepting any blame. Further, while there is much talk about combating the problem, the expense of implementing any large-scale use of desulfurization equipment has meant that little of the talk has been matched with action.

> So long as control of emissions remains expensive, China will likely maintain that, given its relative poverty, sulfur dioxide emissions controls can only be phased in slowly, and that absolute levels of acid precursors emissions will rise. China may be willing to discuss limits to the rate of growth of total sulfur dioxide emissions, but talks about reducing total emissions would be unlikely in the near future.[96]

2. Carbon Emissions in China

China is the world's second largest emitter of carbon, behind the United States. In 1996, China emitted 804 Mtons of carbon, 13% of the world's total. That total was more than all of Eastern Europe and the former Soviet Union (including Russia) combined. This is why many analysts are critical of the Kyoto Protocol. Without countries such as China and India included, meaningful reductions in carbon emissions are unlikely to occur.

Yet China has a different view on the matter. While acknowledging that carbon emissions are a significant contributor to global climate change, and that their country is a major emitter of carbon, China's leaders still claim that their country deserves exemption

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[96] Sinton, 12.

from emissions limitations. Instead of discussing absolute levels of emissions, they prefer to talk about per capita numbers. An example that pertains to carbon emissions can be found in the 1994 White Paper *Agenda 21*. That document does not mention China's total carbon emissions anywhere in the text. Instead it points out that "by the year 2000, China's per capita emissions of carbon dioxide will still be less than one half the world's average of 1.2 tonnes per head, or one sixth of the 3.3 tones per head average of industrialized countries."[97] A response to this type of comparison is that regardless of population size, China is on e of the world's most carbon intensive country, meaning it emits very high amount of carbon per Btu of energy used.[98] Nevertheless, Beijing is quick to dismiss any environmental criticism from the U.S. who is the world's largest carbon emitter. However, *Agenda 21* is at least an acknowledgement that action must be taken on this problem, when it states that "China wishes to bring the emissions of greenhouse gases under control."[99]

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[97] *Agenda 21: White Paper on China's Population, Environment, and Development in the 21st Century*, Chapter 18, 10. This white paper is available from the official Chinese government Agenda 21 web page [Online]: http://www.acca21.edu.cn/ca21pa.html. [November 17, 1998]

[98] *Energy Use and Carbon Emissions: Some International Comparisons*, U.S. EIA, Office of Emerging Markets and End Use Publication DOE/EIA-0579(94), (Washington, D.C.: U.S. DOE, April 1994), 9.

[99] Ibid.

D. OPTIONS FOR REDUCING ENERGY SECTOR EMISSIONS[100]

This section will explore a variety of general options available to reduce energy sector emissions, and examine their applicability in China. Most of the discussion will center on options for reducing acid gases, as this can be addressed throughout the fuel usage chain, ranging from selection of fuel to the release of emissions. This is because the amount of acid gases emitted, principally sulfur dioxide, is directly related to the amount of sulfur in the fuel. Carbon and nitrous oxide emissions, by contrast, are a by-product of carbon, an integral part of fossil fuels, and nitrogen and oxygen from the combustion process. Therefore, these can only be addressed at the combustion and emission phases.

1. Conservation and Efficiency

The obvious place to start in reducing emissions, is to simply reduce energy consumption. In absolute terms, this is not even a remote possibility in China. The Country's energy usage will grow, not diminish. The only question is how fast it will grow. This is where conservation and efficiency can play a role, and to a certain extent, they are already important to meeting China's energy needs.

One way of measuring the extent of efficiency is using the concept of energy intensity, which is the ratio of energy use to unit of economic output.[101] As Xiannuan Lin

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[100] The six general categories that follow are based on divisions in Park, 139-148. Much of the material in these sections is based on the work, supplemented as indicated.

[101] This can be expressed in a variety of ways by using different units. This thesis will express it in the units used by the EIA, which is thousands of Btu per dollar of GDP.

discusses in the introduction to *China's Energy Strategy*, energy use in developing countries generally follows a pattern of rising energy intensity.[102] This normally reflects the society's shifting of resources from sectors with relatively low energy usage, like agriculture, to more energy intensive sectors, like heavy industry. Eventually, as a society develops further, it transitions from a complete reliance on heavy industry for growth, and diversifies into lighter industries and services. This normally results in decreasing energy intensity. China seems to be an anomaly. By most measures, China is still in the early stages of development, with an emphasis on manufacturing as an engine of growth. Yet as Figure 3. shows, energy intensity in China has been steadily decreasing since Deng Xiaoping's reforms were implemented. Energy intensity today is less than a third of what it was twenty years ago.

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[102] Xiannuan Lin, *China's Energy Strategy* (Westport, CT: Praeger, 1996), 1-2. See also Gerald Leach et al, *Energy and Growth: A Comparison of 13 Industrial and Developing Countries* (London: Butterworths, 1986), 27-30; and U.S. Congress, Office of Technology Assessment (OTA), *Energy in Developing Countries*, OTA-E-486 (Washington, D.C.: U.S. Government Printing Office, January 1991), Available [Online]: http://www.wws.princeton.edu/~ota/ns20/pubs_n.html.

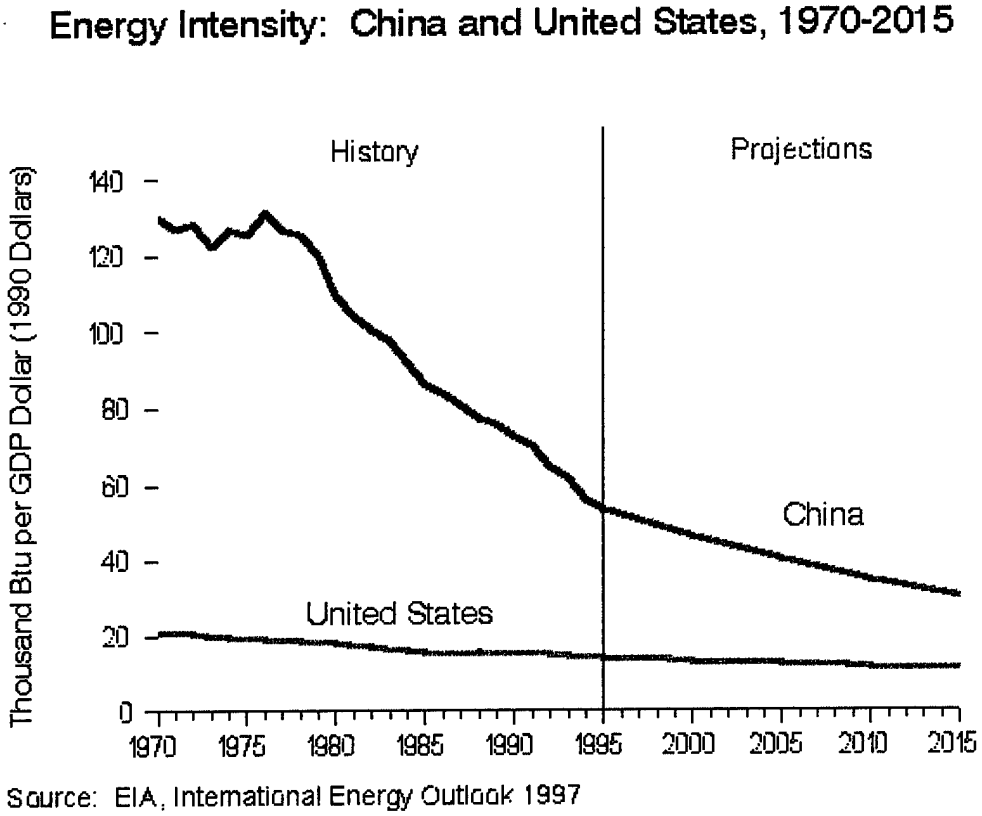

Figure 3. U.S. and China Energy Intensity[103]

Explaining this anomaly is the subject of Xiannuan Lin's book. The short answer is that China truly is becoming more efficient as it develops. This apparent paradox is due largely to the vast size and diversity of China. There are drastic economic differences between remote western provinces and advanced coastal regions. The eastern provinces are indeed well along in the development process, and these economies are moving away from a dependence on heavy industry. This diversification adds to direct conservation gains to help reduce China's overall energy intensity.

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103 From "China: Energy Situation," U.S. EIA (1997), 7, Available [Online]: http://www.eia.doe.gov/ emeu/cabs/china/part2.html#ENERGY. [October 10, 1998]

Yet China's developmental diversity only reveals half of the picture. The other half provides another indication of Beijing's pragmatism. China's leaders have known for several years that an energy crunch was coming and have been exploring all options to avert it. After the oil crises of the 1970's, energy policy began to get more attention worldwide, not just in China. As will be seen, this led Beijing to focus on coal, as China's dependable and secure resource. At the same time, however, they began to think about efficiency. In the Deng era, this thinking gained momentum, and as more industries began to operate on sound business principles, conservation and efficiency became a part of doing business. In recent years, it has become a central part of China's development policy, as indicated through documents like *Agenda 21*. That document recognizes that China's industry as a whole is still quite wasteful, and that there is a future role for efficiency. This passage illustrates the point:

> Energy consumption per unit output in China is 3-4 times that in developed countries. Energy consumption for manufacturing major industrial products is 40 percent higher than that in foreign countries. The average energy utilization rate is only around 30 percent, while in developed countries, it is over 40 percent. Therefore, there is a great potential for energy conservation in China.[104]

Agenda 21 goes on to establish the goal of meeting fifty percent of incremental energy demands through conservation by the year 2000.[105] While this is probably a bit ambitious, it emphasizes the awareness among China's leaders that efficiency is

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[104] *Agenda 21*, Chapter 13: 7, Section B, para. 25.

[105] Ibid, Chapter 13: 7, Section B, para. 29.

important. The ninth five-year plan reflects this and sets a more achievable goal of increasing efficiency by five percent annually.[106]

2. Fuel Switching

This option reduces emissions by switching energy reliance to lower polluting fuels, like natural gas. The scope of the growing need in China and, as will later be demonstrated, the emphasis on security as the number one aspect of energy policy, limit the role this option can play in China. It is doubtful that this method alone could ever meet China's demand, let a lone actually reduce emissions. It can, however, contribute to reducing the growth in emissions if newer power plants and industrial facilities are built to use cleaner energy sources.

China is pursuing this avenue, to a certain extent. The following chapters will reveal the true potential of various fuel sources, but the general situation is that while natural gas will play an increasing role in China, it will remain a relatively insignificant role for many years. Instead, China will try to use other "clean" sources like nuclear power and hydroelectric power to help meet growing needs and reduce emissions. The role of each of these will likely increase in China. Correspondingly, the overall portion of

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[106] See "China: Energy Situation." For a particularly optimistic view on the role efficiency will play in meeting China's energy needs, see "Energy Problems in China's Economic and Social Development," (Beijing) *Jingli Guanli* in Chinese, no. 11 (November 1997): 8-9, FBIS Document ID FTS19980708000402. This article thinks that conserving energy resources is the "principal solution" to meeting China's needs, and states that energy conservation alone could support an eight percent growth rate.

China's energy needs that is met by coal will decrease slightly, though absolute use will increase, and it will remain the dominant fuel in China for many years.[107]

Aside from completely switching fuels, this option also includes such ideas as focusing on using coal reserves with a lower sulfur content. China is attempting to do this, through reform of the coal industry.[108] However, this avenue alone will have limited success due to a variety of factors that will be analyzed.

3. Fuel Desulfurization[109]

This option involves mechanical or chemical processes to reduce the sulfur content of fuel before it is burned. The most common method is "coal washing." This process involves grinding coal into small, dust-sized particles that are then floated on water. Sulfur and other mineral impurities sink, allowing the coal to be separated. It is then dried in a stream of hot air, usually generated by burning some of the coal, a process that usually consumes no more than two percent of the coal.

This process removes up to thirty percent of the raw coal as ash, meaning the remainder is cleaner. This cuts down on the transportation requirement by removing extraneous weight. The washing normally removes 40-60 percent of the loose sulfur in the ore, but SO_2 emissions are generally reduced by only about 8-15 percent. This

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[107] See "Coal to Have Less Dominant Role in China, Say Experts," *Asia Pulse* (August 24, 1998), and "China's Energy Resources to be Diversified in Next Century," *Asia Pulse* (August 28, 1998).

[108] This will discussed in Chapter V.

[109] This process is described in detail in Park, 144-145.

process cannot remove sulfur that is chemically bonded to the coal. Coal washing is considered relatively cheap, costing approximately $1-$6 (U.S.) per ton. The process is also relatively simple, therefore it can be applied in remote areas with limited technical expertise.

Yet coal washing is not the cure-all for China, as reflected by its minimal usage. To begin with, the minimal cost can seem excessive when large quantities are involved. Further, China has never factored environmental impact into cost evaluations, so the coal industry has been reluctant to increase its usage. Also, coal washing uses a great deal of water, and produces liquid and solid wastes that have their own disposal problems. Some of the resultant ash can be used in the cement industry and other enterprises, but most large-scale coal mines are not geographically situated to take advantage of this option. Therefore, the waste becomes an added burden with associated costs. The amount of water used is also a concern in some areas. Many of China's large coal bearing regions are located in arid zones where water can be a scarce commodity for parts of the year. A final shortcoming of coal washing is simply that it is not very effective when compared to other options.

A more effective method of removing sulfur from coal is through chemical cleaning. This process can remove up to 95% of the inorganic sulfur and half of the organic sulfur. However, this process is not applicable in China for two reasons. First, it is much more expensive than washing, adding $20-$30 per ton. With the minimal cost of washing acting as a disincentive, this process would not even be considered in China.

The second disadvantage precludes any near-term usage anyway, because this process is only in the developmental phases, and could not be applied in China for several years, even if the desire existed.

Another method of removing sulfur from coal is by converting the coal to a gas or liquid fuel through processes know as gasification of liquefaction. During this conversion, the sulfur is removed. This method is quite effective, producing a very clean and efficient fuel. It is also, unfortunately, prohibitively expensive for large-scale use almost everywhere, and China is no exception.

Sulfur can also be removed from liquid fuels, such as crude oil. This, too is quite effective, but can add 20-35 percent to the cost of refining the oil. This puts liquid desulfurization in the same category as coal liquefaction. Both stand little chance of successful penetration in China.

The result of all of these methods is that the option of fuel desulphurization is technically possible, but economically questionable as a basis for reducing sulphur emissions.[110] The only one of these methods that is likely to see any wider usage in China is coal washing, and its application, and effectiveness, will be limited.

4. Reduction of Pollutants During Combustion

This approach for reducing SO_2 emissions involves new types of burners and boilers to minimize the release of sulfur during the combustion process. The most common application, though there are many variants, is called fluidized bed technology

[110] Park, 145.

(FBT).[111] This mixes lime with the fuel, which then attaches to the sulfur and falls out as solid waste, thus preventing it from escaping with the exhaust gases. A specific type of FBT, called atmosphere fluidized bed combustion (AFBC) is a relatively proven technology that is in use in some small power plants in China. These systems can reduce SO_2 emissions by 70-90 percent. The units also have reduced NO_x emissions because they operate at a lower temperature than conventional burners.[112] Aside from lower boiler temperatures, NO_x emissions can be reduced by limiting the excess air exposed to the combustion process. Most of these methods result in NO_x emission reductions in the range of 30-40 percent.[113]

All of these systems have some potential in China, but there are numerous drawbacks as well. To begin with, many of the more effective designs are only in the demonstration phases, either in the U.S. or Japan. These are years away from commercial applications in China. Also, these units add to the capital cost of new facilities, though they cost less than some other options, which will be discussed. Finally, they cannot be added to existing facilities; meaning they are only an option in future construction.

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[111] FBT systems are described in Park 145-146.

[112] For more on AFBC and some other FBT variants, see David Von Hippel, "Technological Alternatives to Reduce Acid Gas and Related Emissions from Energy Sector Activities in Northeast Asia," ESENA, the Nautilus Institute, (November, 1996), 6-8, Available [Online]: http://www.nautilus.org/esena /papers/dvhtech.html

[113] Park, 149.

5. Reduction of Emissions from the Exhaust Stream

This option is the only effective way of reducing carbon emissions, and one the of the most common techniques applied to SO_2 and NO_x emissions. ESENA (Energy, Security, and Environment in Northeast Asia) calls systems in this category end-of-pipe solutions.[114] A common name for one type of end-of-pipe system is a scrubber. There are various types of scrubbers that are designed to remove either SO_2 or Carbon.

A standard practice for removing sulfur is called flue gas desulfurization (FGD).[115] FGD involves passing exhaust gas over or through a substance to remove, or scrub, the sulfur before releasing the exhaust. The most common substances used are carbon (dry scrubbers) and lime (wet scrubbers), though other materials are being used in demonstration and experimentation units. The oldest version is the lime based wet scrubber that has been in use since 1929. Accordingly, these are the most widely used FGD systems and the least expensive, although the are still quite costly. This makes them the most likely to be employed in China.

The newer scrubbers that are being developed offer tremendous advantages over lime scrubbers, though they will also cost a great deal more. The lime systems produce a solid waste that must be treated and then deposited in a landfill. The waste from the newer systems can be processed to provide commercially marketable sulfur and sulfuric

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[114] These solutions are discussed in Von Hippel, "Technological Alternatives to Reduce Acid Gas and Related Emissions from Energy Sector Activities in Northeast Asia."

[115] See Park, 146-148.

acid. The sale of these products can help defray the capital outlay for the systems. However, like many other technological emissions control methods, the current developmental state of these scrubbers precludes their wide spread use in China.

FGD is the most common end-of-pipe solution, but there are many more in various stages of development.[116] All sulfur scrubbers are very effective, generally removing 70-90 percent of sulfur, and most also remove particulates, and some NO_x gas, making them an all around effective emissions reduction tool. Additionally, they can be retrofit into existing facilities, as well as installed in new plants. Their main limitations are their high cost, and with those currently available, the extensive generation of solid wastes.

There are also end-of-pipe systems specifically for treating NO_x emissions. One of the more effective is flue gas recirculation, which diverts the gases back through the combustion chamber to help reduce the amount of air present. This can result in a 30-40 percent reduction in NO_x. Another option is flue gas cleaning, which attempts to remove NO_x from the exhaust stream. This is a difficult process, as NO_x is a very stable gas, and as a result these systems have a low effectiveness, usually around 20%. Since lime scrubbers also aid in the reduction of NO_x emissions, there are new systems being developed that combine this with a separate NO_x removal system to target both SO_2 and NO_x. As with many other options, however, these are still in the early developmental stage, and will undoubtedly be quite expensive.

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[116] See Von Hippel, "Technological Alternatives to Reduce Acid Gas and Related Emissions from Energy Sector Activities in Northeast Asia."

Carbon scrubbers fall into the end-of-pipe category as well. These systems inject an absorbing metal, alcohol, or some other substance into the exhaust stream at low pressure and high temperature, which increases CO_2 recovery. While these systems are very effective, they take a toll on a power plant in the form of decreased thermal efficiency. Reductions from 41 percent to 30 percent are characteristic in a coal-fired plant. They also have a high cost, usually around $41 per ton of CO_2 removed. A further limitation of these systems is that they are difficult to combine with SO_2 scrubbers, as the materials used are adversely affected by SO_2.[117]

There is a new system being developed that will combine the best of all of these. This system is a carbon scrubber that uses a variation of flue gas recirculation. The combined process removes most of the oxygen from the air before SO_2 and NO_x can form. As if that were not enough to sell it, this system is expected to cost only $22 per ton of CO_2 removed. Unfortunately, this system is absolute state-of-the-art technology and is years from commercial deployment.

6. Flue Gas Dispersion

This final alternative was popular for many years, both in China and in the West. The intent was to disperse the gases enough that the environment could then absorb them. This led to the "tall stacks policies" seen in Britain and the U.S. in the early 1970's. It

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[117] For more on the interaction of the various emissions reduction systems, see David Von Hippel, "Global Dimensions of Energy Growth Projections in Northeast Asia," ESENA, the Nautilus Institute (November 1996), Available [Online]: http://www.nautilus.org/esena/papers/dvhglobal.html. [August 31, 1998]

has since been realized, however, that all this did was to move the problem further from the source. It did indeed disperse the emissions, but the environment could still not absorb them. There are still many remnants of this mentality around but fortunately, even in China, this approach is no longer seen as a valid emission reduction plan.

E. OUTLOOK FOR EMISSION REDUCTION IN CHINA

The general picture painted is that while there are some improvements China can make to reduce emissions, most technologies that will have any true impact will require at least outside assistance, if not financing as well. The added expense involved for most solutions will prevent them from being considered in China.[118] While cost does not seem to be a major consideration to Beijing when it comes to obtaining and securing energy, it does seem to play a major role in environmental protection. While Agenda 21 seems to indicate a determination on the part of China's leaders to protect the environment and find paths to sustainable development, there is every indication that they lack the capacity to enforce the new regulations. The largest obstacle is that while decisions are made in Beijing, they most be implemented by local authorities who stand to lose from any local economic burden imposed.[119]

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[118] An alternative view is presented in Robert H. Williams, "The Potential for Reducing CO_2 Emissions With Modern Technology: An Illustrative Scenario for the Power Sector in China," *Science and Global Security* 3 (1992): 1-42. Williams presents a fifty-year plan for development of new industries specializing in environmental protection and renewable energy equipment. He envisions these industries spurring a technological boom and the new systems actually paying for themselves in energy savings. This is a remote possibility in any country, and extremely unlikely in China, even in fifty years.

[119] See Hughes, "Pollution with Chinese Characteristics."

This will mean that efforts to combat SO_2 emissions will be more successful than attempts to control carbon. This same pattern will hold true at the national level as well. This is because acid deposition is largely a localized phenomenon. Local leaders—and on a larger scale, national leaders—see the effects of acid deposition in their regions and on their neighbors. Therefore it is more likely to be seen as a threat. Global climate change, while potentially catastrophic, is not visible to the average person and it will be harder to garner support for efforts to combat it in China.[120]

[120] See Gan, 123.

V. FOSSIL FUELS IN CHINA

A. COAL

Coal is the most abundant fossil fuel in the world, the largest single source of fossil fuels in use in the developing world, and it represents approximately 70% of energy use in China. This is due to a number of factors, the most significant being China's extensive indigenous reserves. Coal worldwide is heavily concentrated, with China, the former Soviet Union, and the United States possessing about two-thirds of the world's total. China ranks third in that list with recoverable reserves conservatively estimated at 114.5 billion tons. [121] In actual annual coal production, China leads the world at 1,116 million tons (Mtons).[122]

Aside from the ready supply, coal has many advantages when compared to other fuel sources:

> Per unit of heat value, coal is cheaper than oil and in most cases, gas. Coal is a familiar fuel with a long established technology. Finally, coal mine capital costs are low and in many countries [including China] have a high content of locally manufactured goods and services.[123]

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[121] McCreary et al, II-3, 4. This number is an estimate, as the extent of reserves in China is very dificult to ascertain due to different accounting systems, and dubious data. For an example of the difficulty of obtaining a true figure from a government source, see Zhang Zheng, "China's Proven Coal Reserves Not Very Abundant," (Beijing) *Zhongguo Guoqing Guoli* , No.7, in Chinese (July 1998): 34, FBIS Document ID FTS19980909000395.

[122] The U.S. ranks second at 823 Mtons.

[123] U.S. Congress, Office of Technology Assessment (OTA), *Fueling Development: Energy Technologies for Developing Countries*, OTA-E-516 (Washington, D.C.: U.S. Government Printing Office, April, 1992), 231, Available [Online]: http://www.wws.princeton.edu/~ota/ns20/pubs_n.html.

These reasons make coal not only affordable and dependable, but—more importantly to China—secure. The coal industry in China is almost completely self-sufficient and can provide large amounts of coal at a steady pace, guaranteeing an uninterruptible energy source. Chinese officials realize that coal is their most secure resource, and then Premier Li Peng recently outlined China's plan to continue its heavy use.[124]

At first glance, China's increased reliance on coal appears relatively benign. Coal bearing sediment covers 5% of China's territory and there are deposits in every province. Approximately 79% of China's reserves are bituminous coal that has a very low sulfur content (less than 1%) and is in high demand worldwide for high-grade steam and coking applications. Aside from providing China with a dependable energy source, these reserves could also bring in outside capital, as their high quality makes them quite marketable. A further 6% of China's coal is anthracite, or hard coal, which is also relatively low in sulfur content. Due to this ready supply, coal has fueled the growth of modern China. Aside from its vast use in electrification, it has been the dominant fuel in most industrial applications. Until recently, it has powered most of China's trains (many are still coal-fired), and even through the 1980's and to some extent today, it has played a major role in household heating and cooking.

Despite this dependence, coal is not the solution to all of China's energy problems. Aside form the tremendous environmental impact of coal usage, it is also

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[124]"Li Peng's China Energy Speech", originally published in *The People's Daily* (May 30, 1997).

"difficult to handle and transport, and is less versatile than oil. Its variability and frequently poor quality discourages the use of advanced combustion technologies and may contribute to poor power plant performance."[125] This variability in quality is one of the largest negative factors in China. Despite the country as a whole having a preponderance of relatively high quality deposits, this "cleaner" coal is concentrated in massive pockets in just a few areas, principally Inner Mongolia and Shanxi Province. The coal scattered throughout the rest of the country is of mixed quality at best.

This inequitable distribution is further exacerbated by China's deficient transportation infrastructure. The vast quantities of coal required in most applications demands a reliable rail system to transport the needed supplies. China's rail system is completely inadequate for properly distributing all of these high-grade reserves to the nation's steel mills and industrial sites where it would be properly used. It is likewise inadequate for bringing commercially viable quantities of the higher quality ore to suitable ports for export.[126] The DOE estimates that approximately 20 million tons (Mtons) of coal per year goes into storage at mine sites due to a lack of transportation. Also due to inadequate transportation, much coal gets used inappropriately throughout China. In 1988, only 89 of the 463 million tons of coking coal mined were actually used for coking. Most of this high-quality coal ends up being burned as regular steam coal or for household fuel, wasting a valuable export commodity. Further, though coking coal is

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[125] *Fueling Development*, 231.

[126] The inadequacies of China's transportation infrastructure and efforts to correct them will be discussed in Chapter VII.

in demand for specialized use, it actually has a relatively high sulfure content. It use in regular boilers and stoves, without washing, aggravates China's acid rain problem.[127]

The early inability of China's centrally run state coal industry to keep pace with demand led to the growth of numerous small locally run mines. This allowed local industries to fill their energy needs on short notice, and it reduced reliance on the central government. Today, in addition to the 94 key State coal mines, China has 2,500 local state mines, and 75,000 township and village mines. This dispersion of the industry helped alleviate some bottlenecks in the system and dramatically boosted output.

As a result of these changes, most of the coal mined in China is in the south due to abundant, easily accessible reserves in close proximity to China's booming industries. Unfortunately, most of this coal is of very poor quality, producing minimal energy, and it often has a very high sulfur content—as high as 20% in some areas. Extensive reliance on these reserves has increased pressure on China to find alternative energy sources or methods of mitigating the environmental impact of coal. The concern with this increased usage of high-sulfur coal can be summarized as merely converting "energy security into environmental security, for the Chinese themselves; for countries adjacent to China, such as Japan with its acid rain-diminished forests; and for the world at large, fated to suffer significant increases in greenhouse gas emissions."[128] This makes it in the best interests of the United States and the rest of the industrialized world to encourage China to shift to

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[127] Sinton.

[128] Yergin, Eklof, and Edwards, 37.

other resources or help provide "clean coal" technology. Unfortunately, there is no easy solution. While China has shown signs of increased environmental awareness in the ninth five-year plan, it may be difficult to convince Beijing to rely less on coal when China produces fewer green house emissions than the U.S., Western Europe, or the former Soviet Union.

Short of actually switching to another fuel, China has attempted to shift reliance back to cleaner coal sources. While it struggles to increase the transportation capabilities, Beijing has taken steps to reform the coal industry. The massive increase in the number of mines that occurred during the 1980's has led to massive overcapacity in the 1990's. The government estimates that current nationwide stockpiles of coal reached 65.68 Mtons at the end of June 1998.[129]

To reduce these stockpiles and enforce new safety and environmental rules, Beijing plans to close 22,000 small mines that are operating without licenses. This action is expected to reduce total output by 200 Mtons. Control of the 94 state owned mines is being transferred to the provincial governments to allow them to better balance supply and demand within their regions.[130] To allow for future increases in production with expected growth in demand, the central government plans to develop 16 larger,

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[129] Zhao Shaoqin, "Mine Closure Scheme to Overcome Coal Glut," (Beijing) *China Daily*, Business Weekly Supplement, Hong Kong Edition (23-29 August, 1998): 1, FBIS Document ID FTS19980824000448.

[130] Ibid. See also Peng Jialing, "What Should I Manage If I Am Not Managing Enterprises-State Coal Industry Bureau Director Zhang Baoming Discusses Major Changes in Management Functions," (Beijing) *Renmin Ribao* in Chinese (September 18, 1998): 2, FBIS Document ID FTS19980922000445.

automated coal mines located near new power plants. This mine-mouth co-location is to reduce transportation requirements.[131]

While China will see a short term drop in coal production due to this reorganization, coal production will remain capable of absorbing any demand not met by other sources of energy. The percentage of coal usage in China's electricity future—unlike other fuels that will be examined—will not be determined by supply capabilities. Instead, coal will account for whatever portion of future demand that is not switched to rely on other sources. In the subsequent examinations of other fuels, projections will be made for what role each fuel is likely to play in the future. Coal will essentially be whatever is left. This amount will be reviewed in the closing chapters.

B. OIL

Oil plays a central role in the energy picture of most countries, providing 40% of the world's commercial energy.[132] Twenty-five years ago, the same was true in China, but today it is less important. In 1957, sixty percent of the oil used in China was imported. The fear of dependence drove China to aggressively pursue indigenous oil development. Throughout the 1960's and 1970's, China's oil industry experienced 25% annual growth, which allowed it to not only met China's needs, but allowed the country

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131 "China to Implement New Coal Development Strategy," (Beijing) *Xinhua* (0908 GMT, September 30, 1998) FBIS Document ID FTS19980930000326.

132 World Resources Institute (WRI), *World Resources 1996-1997: A Guide to the Global Environment,* WRI Web page, Chapter 12, Available [Online]: http://www.wri.org/wr-96-97/96tocful.html.

to become an oil exporter. This secure position led to a feeling of confidence in oil, which resulted in China building some power plants and industrial enterprises powered by oil.

By the 1980's, demand was soaring and domestic production could not keep pace. In 1993, China became a net importer of petroleum products, and by 1996 the country was a net importer of crude oil, despite being the world's fifth leading oil producer. Beijing began to refocus on energy security as an enabler of growth and started shifting from reliance on oil back towards coal and other fuels. [133] As a result, today, oil's role in China's electrical and industrial sectors is minor. While it is the major fuel in the transportation sector, that sector represents only 10% of China's TPES.[134] Overall, oil represented only 15.8% of commercial energy consumption in China in 1996.[135]

From this perspective, oil would appear to be an unusual place for concern about conflict with China. Yet, this is where U.S. and Chinese interests are most likely to contradict. This is due to three main factors. The first is the fact that—as discussed earlier—oil is likely to assume an increasingly important role in China as development continues. The second factor is that due to the size of China's economy, even though oil may represent a small percentage of the country's energy usage, this is still a very large amount. As China continues to grow, this will become even more significant. The third

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[133] McCreary et al, II-7-II-11. This section provides most of the background on the evolution of China's oil industry.

[134] Ibid, III-5.

[135] IEA, "Key Energy Statistics for China."

important factor is that despite China's aggressive attempts to expand domestic oil production, the gap between demand and indigenous supply continues to widen, leading China to look beyond its borders for a greater amount of oil each year. The paths Beijing is choosing to find this oil and implications for U.S. policy will be discussed later in this chapter. First, an examination of China's domestic oil production will help clarify the scope of China's import needs.

China's oldest and largest oil field is the Daqing field in the Songliao Basin in Heilongjiang Province. Daqing began production in 1959, and produced nearly a quarter of China's oil from 1968-1976. Unfortunately though, Daqing's reserves are typical of much of China's oil in that it is scattered in numerous thin pockets that are difficult to extract. By 1977, Daqing production was declining, as the remaining oil reserves required a higher technical ability than China possessed to maintain production levels.

During the 1980's, China sought and received an infusion of technology and assistance from Western oil companies. Production increased slightly for a few years, but the field has experienced 0% growth since 1985 despite the continuous addition of new wells. A similar situation exists at China's second largest field, Shengli and many other large, older fields. Daqing and Shengli are extremely important to China as the two fields together account for 52% of China's onshore oil production.[136]

As these two fields began to decline, China started looking elsewhere for oil. The greatest hopes have been placed on the Tarim Basin in Xinjiang Province. Early

[136] Fereidun Fesharaki and Kang Wu, "Revitalizing China's Petroleum Industry Through Reorganization: Will it Work?," *Oil and Gas Journal* 96, no. 32 (August 10, 1998): 35.

estimates for this area put oil reserves in the neighborhood of 10 billion tons, and Beijing saw this as the solution to all of China's energy problems. However, as is often the case in China, reality has not kept pace with rhetoric, and more recent estimates of the Tarim's potential reserves by Western oil companies have been as low as 30 million tons.[137] Yet this estimate may be unreasonably low. The true situation is difficult to predict, as exploration and production in the Tarim Basin is extremely difficult, due to the inhospitable climate of the Taklimakan Desert.

The situation has been further hampered by the remote western location. Until quite recently, there was only one single track railway to the region which limited the transport of exploration and drilling equipment into Xinjiang and the flow of oil out. Expansion of production in the area can be directly correlated with the expansion of the rail line, which has spread deeper into the Tarim and allowed further drilling.[138] Additionally, the line was upgraded to double track in late 1995, which more than doubled the freight capacity into and out of the region. In 1990, total oil output of the Tarim Basin was 150,000 tons. This number rose to over 5 million tons in 1996, demonstrating that there are some viable fields in the area when logistics allows them to be exploited. McCreary et al calls the Tarim "currently China's only hope of minimizing oil imports."[139]

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[137] Ahmed Rashid and Trish Saywell, "Beijing Gusher: China Pays Hugely to Bag Energy Supplies Abroad," *Far Eastern Economic Review* 161, no. 9 (February 26, 1998): 46-50, specifically 47.

[138] McCreary et al, II-9.

[139] Ibid.

Bejing agrees, and has continued aggressive exploration. China's National Star Petroleum Corporation (China Star) just recently announced the discovery of a new field in the basin with reserves estimated to be over 100 million tons. The China National Petroleum Corporation (CNPC) announced the discovery of a gas pocket believed to be in excess of 160 billion cubic meters.[140] All together, China claims that after nine years of exploration and development, they have discovered ten oil and gas fields with reserves of 600 million tons of oil.[141] Beijing expects to raise this total to 900 million tons and expand annual production to 18 million tons by 2000.[142] These estimates are probably high, as most previous government figures have proven to be. The *Beijing Review* offers a slightly more believable estimate for the Tarim Basin, putting proven oil reserves at 230 million tons and gas reserves at 100 billion cubic meters.[143] The recent successes in exploration do, however, restore some of the previous hope for the region. Yet the answer to whether or not the Tarim Basin will be China's energy salvation will be a long time in coming. Short term, it seems clear that production will increase, but not at a pace sufficient to prevent imports from climbing.

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[140] "Tarim Basin Set to Become China's Largest Energy Source," *Asia Pulse* (October 13, 1998).

[141] "Present Situation in Tarim Oilfields," (Beijing) *Jingji Cankao Bao* in Chinese (August 4, 1998): 5, FBIS Document ID FTS19980825000669.

[142] "Xinjiang to Accelerate Petroleum Production," (Urumqi, Xinjiang) *People's Radio Network* in Mandarin (1230 GMT, July 20, 1998), FBIS Document ID FTS19980808001471.

[143] Wei Bian, "Oil Industry Enjoys Great Potential for Development," *Beijing Review* 41, no. 25 (June 22, 1998): 15.

China's other hopeful areas for domestic oil production are in its offshore fields, principally in the South China Sea and the Bohai Gulf. The China National Offshore Oil Corporation (CNOOC) anticipates total production for 1996 to reach 16.5 million tons.[144] Most of the fields contributing to this total are still relatively new and are expanding production, which allows this total to continue climbing. Expansion of these fields is underway, and more pockets of oil and gas are still being discovered. New wells were recently added in the Bohai Gulf, and a new field was recently discovered in the Pearl River Basin.[145] The fields in the eastern South China Sea, which only began production in 1990, have stepped up output and are nearing an annual production of 3 million tons.[146]

Increases offshore and at Tarim are quite promising—as well as some smaller successes—but so far, what limited increases in production that have been achieved are insufficient to even offset the declining production from the older, maturing oil fields. So far, they have shown no ability to meet any increased demand. Assuming Tarim and the offshore fields meet their production goals for this year of 5 million and 16.5 million tons, respectively, these two together represent only 13.5% of the total domestic

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144 "Official Anticipates Rise in Offshore Oil Production," (Beijing) *Xinhua* (1257 GMT, September 11, 1998), FBIS Document ID FTS19980911000719.

145 "PRC Stepping up Bohai Oilfield Development," (Beijing) *Xinhua* (0816, July 8, 1998), FBIS Document ID FTS19980708000213; "New Oil Field Found in Pearl River Basin," (Beijing) *Xinhua* (0700, September 21, 1998), FBIS Document ID FTS19980921000128.

146 "South China See Oilfield Output Exceeds 50 Million Tons," *Asia Pulse* (September 3, 1998).

production of 1996.[147] This number is also less than China's 1996 net imports of crude and oil products, which reached almost 23 million tons.[148]

Beijing is hoping to drastically increase oil production in the coming years but even the more optimistic government predictions put 2010 production at only 200 Mtons.[149] This number is probably too high. As the *Guoji Shangbao* article which listed this figure stated, "China's existing oil supply capability is actually very close to the maximum domestic oil production level...[therefore] the prospect of relying on domestic resources for increased supply is slim."[150] Even if this goal is achieved, China will fall way short of the level of production needed for oil to maintain its current share of the TCEC without any increases in imports. As table 4. shows, the gap between the required levels and possible production would be almost 75 million tons assuming low growth,

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[147] 1996 production data is from the Pacific Northwest National Laboratory web page, http://www.pnl/gov/china.

[148] Crude oil imports were 22.62 Mtons, while exports were 15.82 Mtons. Oil product imports were 20.33 Mtons and exports were 4.18 Mtons. Like many large countries China both imports and exports coal and oil. This is due to geographic distribution and to provide an exchange of foreign capital. As already discussed, much of China's resources are poorly located for China to fully utilize them, and it is often easier for areas with high demand, located near a seaport to import energy rather than rely on indigenous sources. Most import figures given in the remainder of this thesis will refer to net figures. These figures are from "Petroleum Imports and Exports," *China Petroleum News*, as reported by Internet Securities, Inc (ISI), Emerging Markets (November 17, 1997). Report is obtainable though not routinely available at: http://www.securities.com.

[149] See "Profile China's Petroleum Industry (Oct 1998)," *Asia Pulse* (October 15, 1998). Also "Key Issues of Energy Development Strategy," (Beijing) *Guoji Shanbao* in Chinese (July 10, 1998): 6, FBIS Document ID FTS19980925001692. This source is the less optimistic of the two, using 200 Mtons as a high goal, while predicting actual production somewhere between 160-200.

[150] "Key Issues of Energy Development Strategy."

and 266 million tons assuming high growth. These differences will have to be made up by increased imports.

Year	Low Growth	Hi Growth	Projected
1996	158.675	158.675	N/A
1997	165.022	171.369	N/A
1998	171.623	185.079	N/A
1999	178.488	199.885	N/A
2000	185.627	215.876	N/A
2001	193.052	233.146	N/A
2002	200.774	251.797	N/A
2003	208.805	271.941	N/A
2004	217.158	293.696	N/A
2005	225.844	317.192	N/A
2006	234.878	342.567	N/A
2007	244.273	369.973	N/A
2008	254.044	399.571	N/A
2009	264.206	431.536	N/A
2010	274.774	466.059	200.000

Table 4. Required Annual Domestic Oil Production (Millions of tons)

C. NATURAL GAS

China's natural gas industry is in its virtual infancy. Throughout the 1970's and early 1980's, Beijing focused its attention on oil and essentially ignored natural gas. Exploration in the country was minimal, and little investment was made in gas infrastructure. When in the 1990's it became clear that oil could no longer solve all of China's energy problems, and the externalities of coal usage began to gain attention, natural gas resurfaced.

Since then, there has been a great deal of exploration by China's state run oil companies, and some by outside companies, with reasonable success. Coal, oil, and gas are usually present in similar geological structures, therefore, based on China's reserves of the first two, it was assumed that the country would have extensive gas reserves as well. Most major oil producing countries extract gas and oil in an approximately 1:1 ratio. China's current gas:oil recovery ratio is 0.107:1.[151] It is widely believed that this ratio can be rapidly expanded.

Exploration has found much of the expected gas, but China is not yet willing to commit any major portion of its energy needs to gas. In 1996, it supplied only 2% of China's energy. This is due to a variety of reasons. Without a reliable long-term supply, China is reluctant to shift many energy users over to natural gas despite its environmental benefits. Environmental groups try to show how switching China's electrical generating industry from coal to natural gas would be beneficial for China as well as her neighbors due to its environmental benefits. Such an idea is central to all plans for helping China reduce emissions. Other analysts try to show how natural gas plants entail lower capital costs than coal plants.[152]

While China is aware of these claims, security of the energy supply is the number one priority and a secure natural gas supply is not yet available. The limited supply that is

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[151] McCreary et al, II-12.

[152] See for example Jeffrey Logan and William Chandler, "Natural Gas Gains Momentum," *The China Business Review* (Jul-Aug 1998): 40-44; also "China: It Takes Just One Spark," *The Economist Intelligence Unit* (September 28, 1998), Available [Online]: Mead LEXIS/NEXIS/ASIAPC/ CURNWS/China and natural gas. [October 14, 1998]

available in China is viewed as too valuable for power generation. Instead the majority of it is used in fertilizer production as this is seen as essential to helping feed China's huge population. The small remainder is used in a variety of applications, largely in household heating.[153] Related to this problem is the expensive infrastructure needed to support increased gas usage in China. Even once dependable reserves are secured, transporting gas requires either extensive pipelines or liquefaction facilities. Construction of these raises the cost for China to take a "leap of faith" to gas.[154]

An additional obstacle to China expanding gas usage is the emphasis on using the state owned oil companies to develop indigenous reserves. Natural gas requires more sophisticated technology to exploit than oil, and the state owned oil companies have little experience in this area, and are having little success. Outside observers say that for China to overcome this obstacle, they must open prime parcels for exploration by outside firms. Today, parcels are only opened to Western firms after the state owned companies have explored them. This limits success and delays production.

Another side effect of China's desire to internalize the gas industry is that gas prices are fixed artificially low in China. The current international market price of natural gas is about $100 (U.S.) per 1300 cubic yards and China's internal price is only about $75. This makes it difficult to attract as many outside companies as the country needs to

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153 Ian Johnson, "For Chinese, Natural Gas is Growing in Importance," *Wall Street Journal*, (August 26, 1998): A19.

154 The required faith is in the belief that China's relations with the developed world will remain as favorable as they are today. China's aversion to dependence on outside powers makes a reliance on gas seem undesirable, at least until China can further develop its own gas industry.

develop questionable fields since they see no financial incentive to enter China's market.[155]

Despite these obstacles, China desperately needs to develop the gas industry to absorb growing energy needs. Aware of this, Beijing has become more proactive in exploiting opportunities. Though gas production in 1997 was only 21 billion cubic meters (cu m), officials have set ambitious goals of 72 billion cu m by 2010, and 95 cu m by 2020. These goals are likely unachievable under the current approach, but Beijing seems committed to taking the necessary action to attract foreign investment to transform the industry.[156]

This changing attitude is paying off, as there have been some recent successes in Chinese gas production. The most notable of these is the Yacheng-13 field located 90 kilometers off Hainan Island in the South China Sea. This field—which is estimated to contain as much as 300 billion cu m of gas—began production in January 1996, providing energy directly to Hong Kong's Black Point power plant. This success was only achieved after a $1.1 billion investment that included construction of a 1050 kilometer sub-sea pipeline, the second longest in the world. Additionally, the involvement of a western oil

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[155] For a review of these and other obstacles to further development of China's gas industry see Logan and Chandler, "Natural Gas Gains Momentum." This article is further developed as Jeffrey Logan and William Chandler, "Incentives Needed for Foreign Participation in China's Natural Gas Sector," *Oil and Gas Journal* 96, no. 32 (August 10, 1998): 50-56. See also Keun-Wook Paik and Quan Lan, "China Preps to Expand Gas Output and Distribution Amid Challenges," *Oil and Gas Journal* 96, no. 29 (July 20, 1998): 27-32; "China's Gas Quest," *Energy Economist*, no. 199 (May 1998): 8-12; and "China: It Takes Just One Spark."

[156] Paik and Quan.

company, in this case ARCO, was necessary to make this field productive.[157] The success of this venture, makes this appear as a good model for China to duplicate—partnering with a Western oil company to obtain technology and expertise, while retaining control.

On a smaller scale, there have been other success stories. The Qaidam Basin in Qinghai Province is a notable example. This field is approximately half the size of the Yacheng field but supplies gas to 40% of the houses in the city of Golmud. Pipeline extensions are also under construction to supply Dunhuang and the provincial capital Xining. Further plans include connecting the industrial city of Lanzhou.[158] Successes have also occurred in the East China Sea, and in Sichuan and Xinjiang Provinces.[159]

These advances, while encouraging, are merely baby steps along the path that China could take. Natural gas is still an essentially untapped resource in the country that could offer a solution to much of China's energy needs. It is likely that China will have difficulty increasing production enough for natural gas to retain its current share of 2% of TCEC. Under low growth, this would require total supply of 74.1 bn cu m in the year

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[157] See "Country's Largest Offshore Gas Field Introduced," (Hong Kong) *Zhongguo Tongxun She* in Chinese (0754 GMT, September 29, 1998), FBIS Document ID FTS19981001000727; also Kari Huus, "Perseverance Pays: ARCO Will Profit from Patience in Chinese Gas Venture," *Far Eastern Economic Review* 159, no. 1 (December 28 1995-January 4, 1996): 120-122.

[158] Johnson.

[159] "Pudong New Area to Burn Natural Gas From East China Sea," (Beijing) *Xinhua* (1236 GMT, August 18, 1998), FBIS Document ID FTS19980818000738; "First Offshore Oil and Gas Well Sunk in East China Sea," *Asia Pulse* (October 14, 1998); "New Natural Gas Field Holds 100 Billion Cubic Meters," (Beijing) *Xinhua* (0225 GMT, September 30, 1998), FBIS Document ID FTS19980929001640; "Large Gas Field Discovered in Xinjiang," (Beijing) *Xinhua* (0909 GMT, August 7, 1998), FBIS Document ID FTS19980807001481.

2010. Assuming high growth, this would require supply of 125.7 bn cu m. Assuming China achieves the production goal of 72 bn cu m, this will leave a gap that must be filled by imports of 2.1 bn cu m under low growth and 53.7 under high. China can probably meet most of these needs through planned import scenarios that will be discussed in Chapter VII. However, unless China changes its approach and takes steps to aid the development of its indigenous gas industry, this potentially helpful energy source will not assume any greater percentage of China's consumption. If the high growth rate occurs, its share will either fall, or imports will have to increase. In either of these scenarios, natural gas seems destined to follow oil down the path of becoming a source where China must depend on imports. The tragedy is, that this does not have to occur. It is the fear that it will that prevents China from committing enough demand to gas to justify the investment needed for increased production to prevent these fears from being realized. China likely has sufficient gas reserves to support heavy increases in production, but lacks the will.

Most analysts would like to see this share expanded, and of all of China's available energy options, gas is the one that could most likely be expanded. Increased usage here could possibly shift China more away from coal and lessen the long-term impact of oil imports. This would benefit China by providing a secure fuel source and it would benefit the world through reduced environmental degradation. Unfortunately, as mentioned, expanding the role of natural gas in China faces many obstacles. This is one area where the policies of the U.S. and other foreign governments can help influence

China's choices. By providing technology assistance to expand the gas industry and encouraging its use in the short-term, China can be shown the benefits of this resource without seeing it as a weakness.

VI. OTHER ENERGY SOURCES

A. HYDROELECTRIC POWER

Hydroelectric power is already an important energy source in China providing 22% of the installed generating capacity and 17% of the actual electricity generated in 1996.[160] It is an attractive energy source for a number of reasons. First, "hydropower is a clean, non-polluting, reliable, long-lasting and renewable energy source."[161] This is one way of mitigating fears of increases in acid rain and GHG emissions in China's future plans. Second, "China has the most abundant hydropower resources in the world, with an estimated potential [of] 380 gigawatts."[162] To date, barely 50 GW of this has been tapped, meaning a vast potential still remains. Third, China is capable of producing most hydropower turbines and other components without outside assistance. This and the fact that once dams are built, they require no external fuel supply makes this an apparently secure energy source for China.

Because of these positive aspects, China has embarked on an ambitious program of hydropower construction. Taking advantage of a presently favorable international

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[160] This represents generation at 77% of capacity. This is due to seasonal variations in water flows that prevent China's hydroelectric plants from using the full capacity year-round.

[161] Richard Hunt and Judith Hunt, "Hydropower: Turning Water Into Light," *Chemistry and Industry* no. 6 (March 16, 1998): 227.

[162] Logan et al, 30. See also McCreary et al, II-14. This potential is the amount considered exploitable out of a theoretical potential of 680 GW. Many proponents of hydropower will refer to the higher number, which overstates the possibilities in China.

climate, China has opened up this market to outside firms to increase the rate of growth in the industry. According to a senior official with the State Power Corporation of China, the country has completed 13 projects with a combined generating capacity of 5.62 GW and is currently working on five more with a capacity of 8.1 GW using 2.88 billion dollars (U.S.) in foreign investment.[163] Beijing is willing to use foreign investment to further development, despite the fear of increased outside influence, because it knows that if the outside world tries to isolate China again, the country will still have the dams, without having to repay the investment. Not that this is in China's plans, but that is why this reliance on outside assistance is not seen as threatening to Chinese security.

Today, China's largest power supplier is a hydropower project. The Ertan Hydropower Station on the Yalong River in Sichuan Province has a capacity of 3.3 GW. This dam, which is still in the finishing stages, used 1.78 billion dollars (U.S.) in foreign investment to speed its completion. This dam, which is the second tallest in Asia and the third tallest in the world, began generating electricity on August 12, 1998.[164]

This station is being hailed as a model as China expands plans for further development. Among other sites, China intends to build 20 more projects along the

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[163] "Foreign Funds Boosting Hydropower Development," (Beijing) *Xinhua* (1100 GMT, July 13, 1998), FBIS Document ID FTS 19980713000862.

[164] For more information on the Ertan Dam, see "Ertan Hydropower Station PRC's Biggest Electric Supplier," (Beijing) *Xinhua* (1322 GMT, August 11, 1998) FBIS Document ID FTS 19980811000638; "China's Major Power Plant Starts Generating Electricity," (Beijing) *Xinhua* (1244 GMT, August 12, 1998) FBIS Document ID FTS 19980812000619; "Xinhua Backgrounder: Ertan Hydropower Station," (Beijing) *Xinhua* (1106 GMT, August 13, 1998) FBIS Document ID FTS 19980813000655; and "Demand for China's Largest Power Station Outlined," (Beijing) *Xinhua* (0655 GMT, August 17, 1998) FBIS Document ID FTS 19980817000141.

Yalong River with a combined capacity of 23.7 GW.[165] One of these, the Jinping facility will be the world's highest concave-shaped dam at 325 meters, and it will have a capacity of 3.66 GW.[166] There are also plans to build 13 dams along the upper Yellow River. The first of these was the Lijiaxia Hydropower Plant in Qinghai Province with a capacity of 2 GW, which began generating electricity in August 1997. Three plants are envisioned for the Qingjiang River. The first, completed in 1994, was the Geheyan Station in Hubei Province with a capacity of 1.2 GW. The second—the Gaobazhou Station—began construction in 1997 and will have a capacity of 252 MW. Plans call for Southwestern China's Hongshui River to see ten projects. The first of these is the 1.2 GW Tianshengquiao facility which is nearing completion.[167] The country is also building numerous smaller dams, still often utilizing foreign investment. An example of this can be found in the recently announced plans for a 45 MW dam on the Getu River in Guizhou Province, using 60 million dollars (U.S.) in foreign money.[168]

All of these projects are dwarfed by China's grandest scheme: the Three Gorges Dam. This project will be the largest dam in the world, and will have 26 high capacity

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165 "Plans Call for 20 New Power Stations on Yalong River," (Beijing) *Xinhua* (0313 GMT, August 20, 1998) FBIS Document ID FTS 19980819001672.

166 "PRC to Build World's Highest Concave-Shaped Dam," (Beijing) *Xinhua* (1144 GMT, August 21, 1998) FBIS Document ID FTS 19980821000706.

167 For more on these projects, see "Hydroelectricity and Other Renewable Sources," in *International Energy Outlook 1998*.

168 "China, U.S. to Build Hydropower Station in Guizhou," (Beijing) *Xinhua* (0110 GMT, August 29, 1998) FBIS Document ID FTS 19980828001534.

turbines producing 18 GW of electricity. This huge dam on the Yangzi River is scheduled for completion in 2009. The magnitude of this dam has revealed some of the drawbacks of hydropower in China. The project requires the relocation of 1.2 million people from 19 cities, 150 towns, and 4,500 villages that will be swamped by the planned 570 feet deep reservoir that is expected to reach 650 km upriver. Archaeologists and historians have been scrambling to search the 50,000 acres of land that will be submerged to record all historic sites before they are hidden forever.

Many people question whether the project will be successful due to the high level of silt in the Yangzi River. Critics claim this will clog the turbines and limit the dam's generating capacity. Officials admit they have not yet fully overcome this problem, and when questioned about this obstacle, they tend to redirect attention to the expected benefits of the project. These include—in addition to the much needed electricity—increased navigation of the upper Yangzi River, and improved flood control for the lower Yangzi Valley. The positive benefits of both of these are also unproven and this dam has many opponents. Regardless, Beijing is pressing ahead with construction.[169]

The challenges of this project will also apply to many other large hydropower dams in China, although to a lesser extent. This may increase the value of building many smaller dams instead of a reliance on such grandiose schemes. Another factor to effect that trend is the geographical mismatch between potential hydropower sites and needed

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[169] For a review of some of the challenges and expected benefits of the Three Gorges Dam, see John Bryan Starr, *Understanding China: A Guide to China's Economy, History, and Political Structure*, (New York: Hill and Wang, 1997), 173-180; Alexander Kuo "Breaking the Wall," Harvard International Review 20, no. 3 (Summer 1998): 28-31; and "Hydroelectricity and Other Renewable Resources," 7-11.

demand for electricity. Most of the promising sites are in southwestern China, in remote mountainous areas. Construction here is quite difficult, especially for projects large enough to provide power on a scale to warrant transmission to distant eastern provinces where the demand is greatest. The eastern and northeastern provinces possess only 6% of China's hydropower potential. This mismatch, and China's poor power transmission infrastructure will prevent the entire theoretical potential from being exploited.

Further, another factor that favors the use of smaller dams is that while China's indigenous ability to build dams is quite respectable, the country cannot yet manufacture high capacity power turbines needed in large dams. These are all coming from foreign suppliers today. If China finds itself isolated again, smaller dams will become more attractive. Hydropower can be most beneficial in helping to increase electrification in rural areas and alleviate some regional needs through the construction of numerous modest sized dams. Already, small hydroelectric stations power more than 40 local power grids. This number will likely increase as this is a secure, relatively inexpensive way to meet expanding energy needs in remote areas.

Despite the obstacles, China's announced hydroelectric plans call for an increase of 3.5 GW of capacity each year through 1999, and an increase of 5 GW per year from 2000 through 2010.[170] Table 5. Projects required capacity to maintain the current 22% of total capacity under high and low growth rates in the business as usual scenario, and projected capacity based on announced plans. If these plans are all met, China will have

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[170] "Foreign Funds Boosting Hydropower Development."

27.5 GW or 30.5% excess capacity in 2010 under the low growth scenario. This would allow hydropower to increase its share of the total projected electricity demand to 29%. Assuming the high growth rate, China will have a capacity shortfall of 35.2 GW or 23% in 2010. This would mean hydropower's contribution would fall to 17%. The difference here will determine whether or not hydropower can help ease the demand coal-fired electrical plants by filling a larger share of total capacity. If low growth occurs, the excess capacity would allow China to preclude the use of 29.6 Mtons of coal, whereas if high growth occurs, the resulting gap would require approximately 37.9 Mtons of coal to assume that demand.[171]

Year	Low Growth (4%)	High Growth (8%)	Planned Growth
1997	54.08	56.16	55.50
1998	56.24	60.65	59.00
1999	58.49	65.50	62.50
2000	60.83	70.74	67.50
2001	63.26	76.40	72.50
2002	65.79	82.51	77.50
2003	68.42	89.11	82.50
2004	71.16	96.24	87.50
2005	74.01	103.94	92.50
2006	76.97	112.26	97.50
2007	80.05	121.24	102.50
2008	83.25	130.94	107.50
2009	86.58	141.42	112.50
2010	90.04	152.73	117.50

Table 5. Required and Planned Growth in Hydroelectric Generation Capacity (GW)

[171] This assumes a capacity factor of 0.3 for hydropower plants and 0.65 for coal-fired plants. An average Chinese coal plant uses 410 tons of coal per Gwh or electricity generated. Figures provided by Jeffrey Logan, AISU, Pacific Northwest National Laboratory.

B. NUCLEAR POWER

Another possible source of energy for China—one that is even more fraught with political pitfalls—is nuclear energy. Despite downfalls, this route shows great promise to China due to its inherent efficiency and an internal supply source. China's current uranium reserves are roughly 1.7 billion tons, representing a relatively cheap, and very secure source of power. The cost of transporting uranium is one-hundred-thousandth of that for the volume of coal yielding the same energy.[172] A single truck can transport 160 metric tons of uranium, which can fuel an average power plant for five years. A typical thermal power plant requires five train-loads of coal every day. Also, China's uranium reserves are scattered in over 200 deposits throughout much of the country, providing a ready resource almost anywhere. Increased reliance on this fuel source could provide some relief for China's overburdened transportation infrastructure, and help reduce coal bottlenecks. This makes nuclear power look very attractive to China.

Today, nuclear power accounts for only about one percent of China's total electrical generation capacity. This is due to China's relatively late entry into the civilian nuclear arena, with the first power plant just becoming operational in 1993. This plant—the Qinshan plant in Zhejiang Province—was a timid first step. It is a single pressurized water reactor (PWR) of Chinese design, with a generating capacity of 300 MW.[173] This

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[172] "One Kilogram (kg) of uranium produces up to 50,000 Kilowatt Hours (kwh) of electricity, while one kg of coal produces only up to 3 kwh of electricity." Spodak, 25.

[173] For details on China's nuclear industry and future potential, see Logan et al.

was primarily a study of feasibility to show China's ability to design and build a modern nuclear power plant. The second facility—at Daya Bay in Guangdong Province—was a much larger unit, comprising two 900 MW PWR reactors of French design. This facility became operational in 1994.

There are currently four more plants under construction comprising eight reactors with a combined generating capacity of 6.65 GW. These plants are scheduled to become operational between 2003 and 2005. This represents a substantial commitment to increase the role of nuclear power in China, but is only a small step towards the ambitious goals set out in China's ninth five-year plan. That document planned to raise the current nuclear generating capacity of 2.1 GW to 50 GW by 2020 and 150 GW by 2050.[174] These goals were seen as overly optimistic due to the extensive capital requirement and long construction time for nuclear facilities. In actuality, China will probably build one plant per year through 2010, then possibly three to four per year thereafter.[175] Projections for the tenth five-year plan put the target for 2020 at 40 GW.[176]

As with many other technological solutions to China's energy needs, nuclear power's potential is partially limited by China's production capabilities. The country has a demonstrated ability to design and build safe nuclear plants, but approximately 30% of

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[174] Spodak, 26.

[175] Peng Kai-lei, "Nation to Build 1 Nuclear Power Station Per Year," (Hong Kong) *Wen Po* in Chinese (July 16, 1998): A2, FBIS Document ID FTS 19980720001510.

[176] Si Liang, "U.S. European, and Japanese Corporations Are Marching Towards China's Nuclear-Power Market," (Hong Kong) *Zhongguo Tongxun She* in Chinese (1107 GMT, July 23, 1998), FBIS Document ID FTS 19980806003709

the components in these plants are imported due to China's limited production ability. Many of these components are relatively simple items, but they comprise specialty metals with strict purity and quality control requirements that exceed current Chinese capabilities. Aside from these limitations, the largest barrier to a truly indigenous nuclear industry is China's inability to manufacture high capacity power turbines at a competitive price. These items are similar to those used in large hydropower projects, so once again, larger scale use of this energy source represents an increased reliance on outside assistance.

This is, however, only a short-term obstacle, as China is attempting to upgrade its turbine production abilities, largely through the use of technology transfers. Additionally, this reliance would only be necessary during construction, and does not require any long-term dependence. For these reasons, China is pressing ahead with nuclear expansion plans while the rest of the world—with the notable exception of Japan—is scaling back reliance on nuclear power. This expansion is one of many areas in China's future energy plans that offer excellent business opportunities for outside firms.[177] If the U.S. refuses to deal with China in this arena due to proliferation fears, European and Russian firms will not share such reservations, and China will proceed on course, with the only losers in the deal being U.S. companies.

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[177] Ibid. Also Si Liang, "U.S. European, and Japanese Corporations Are Marching Towards China's Nuclear-Power Market," and "Korea, U.S., Japan Compete for China's Nuke Power Plants," *Asia Pulse* (October 27, 1998).

This increased reliance on nuclear power frightens many observers, so a look at some of the potential problems is warranted. The first concern is the level of safety at Chinese facilities. Memories of Chernobyl cause valid questioning of whether China possesses an adequate level of technological ability to make safe plants. Aware of these fears, China has emphasized safety in all of its nuclear plans.[178] Three of the four new facilities will be built by western companies (French, Canadian, and Russian) or with assistance by them using foreign designs. This will give China's fledgling nuclear industry more time and assistance to develop internationally accepted practices in the construction of their plants.

Since 1981, the U.S. Nuclear Regulatory Commission (NRC) has been assisting China in updating and enforcing new safety regulations and standards. China is moving toward standardization in its future plants, something that is seen as a positive step in improving safety. Additionally, China cooperates openly with International Atomic Energy Agency (IAEA) safeguards to help prevent accidents and limit proliferation possibilities.[179] While not guaranteeing there will be no Chinese Chernobyl, these steps show that China is aware of the potential hazards of nuclear power and is addressing the dangers.

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[178] For a discusison of the importance Chinese leaders put on safety in their nuclear plans, see "China Goes All Out to Ensure Safety of Nuclear Plants," *Asia Pulse* (September 23, 1998).

[179] See Gerald L. Epstein et al, *Nuclear Safeguards and the International Atomic Energy Agency*, Office of Technology Assessment Publication OTA-ISS-615 (April 1995).

A second issue with nuclear power is the generation and disposal of nuclear waste. There are two separate concerns here. The first is the problem of finding a suitable, long-term solution for disposing of waste expected to remain radioactive for thousands of years. A viable answer to this problem has yet to be found in any country, and it is unlikely that China will develop one that can satisfy international critics.[180] The second concern with waste from nuclear plants is the generation of plutonium. All commercial reactors produce some plutonium. The newer ones do not produce it directly, but do produce waste that can be reprocessed to produce plutonium, which can then be used to make nuclear weapons.[181] While China is already a declared nuclear state with the world's third largest stockpile of nuclear weapons, this stockpile is relatively small. Many fear that this could change if China increases reliance on nuclear power. Another great concern is that even if China does not increase its stockpiles, this plutonium could spread to non-nuclear nations. As will be seen, China is willing to deal with Iran and Iraq when they see benefits from doing so. These two countries, as well as North Korea, are among those who seem to possess genuine nuclear plans.

While many groups like those cited above stress these dangers, there are probably few causes for immediate concern. Even the NCI admits that China has an extremely

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[180] For a review of the various options for the disposal of nuclear waste, see Liu, 114-119.

[181] See numerous reports of the Institute for Energy and Environmental Research available at http://www.ieer.org, particularly, Arjun Makhijani, "Nuclear Power: No Solution to Global Climate Change" and "Fissile Material Basics." See also Paul Leventhal, "The Plutonium Industry and the Consequences for a Comprehensive Fissile Materials Cutoff," from the Nuclear Control Institute, http://www.nci.org.

small plutonium stockpile—smaller even than Japan, Germany, and France—and does not have a commercial reprocessing plant. The Chinese possess the technology to build one, but have not done so, indicating they are satisfied with their nuclear deterrent capability and prefer neither a more offensive nuclear posture, nor to violate the Nuclear Nonproliferation Treaty (NPT) by exporting plutonium.[182] Although there are recent signs that China wants to upgrade its nuclear forces, there is no evidence to suggest that they need a substantially larger stock of plutonium to accomplish this.[183]

Whatever the true dangers or obstacles, it is clear that China will expand its use of nuclear power. To them, it represents a very secure and affordable energy source. Opponents of nuclear power will offer rather convincing arguments against the affordability aspect. In particular, IEER repeatedly attempts to show how a combined cycle natural gas power plant is in all ways more affordable and dependable than a nuclear plant.[184] The weakness in selling this to China is it ignores the fact that China has extensive uranium, eliminating (or at least minimizing) fueling costs. Conversely, as seen, China does not yet have a dependable source of natural gas. The infrastructure

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[182] For further discussion of China and the fears of proliferation, see Robert S. Ross, "Why Our Hardliners are Wrong," *The National Interest*, no. 49 (Fall 1997): 42-51; Lisbeth Gronlund, David Wright, and Yong Liu, "China and a Fissile Material Production Cut-Off," *Survival* 37, no. 4 (Winter 1995-1996): 147-167; Mitchel B.Wallerstein, "China and Proliferation: A Path Not Taken?," *Survival* 38, no. 3 (Autumn 1996): 58-66; and Congress, House, *Implementation of the U.S.-China Nuclear Cooperation Agreement: Whose Interests are Served?*, Hearing before the Committee on International Relations, 105th Congress, 1st session, October 7, 1997.

[183] An alternative view on the issue of nuclear waste in China can be found in William Spodak's "Power Struggle." This article downplays the dangers of nuclear waste, and makes the handling appear quite simple.

[184] IEER, "Nuclear Power: No Solution to Global Climate Change."

requirements to realize one shift the economic balance back in the favor of nuclear power. Also, China has projected an ability to build nuclear plants at a cost far below the world average.[185] More importantly to China—and this is an argument that environmentalists cannot really refute—is security. Once built, nuclear plants require minimal foreign assistance. Natural gas will not be as secure anytime in the next 30 years.

Having seen that nuclear power holds an important place in China's energy future, it is now possible to determine the extent of that position. The goal of 40 GW by 2010 would allow nuclear power to service 10% of the total electricity demand in the low growth scenario, and 6% in the high growth. The original goal of 50 GW would raise the numbers to 12% and 7%. The difficulty is that both of these goals are likely unachievable. The four facilities currently planned or under construction are the only plants that are likely to be operational before 2005. The largest of these plants is 2 GW. As the Peng Kai-lei article cited above noted, a realistic plan has China completing one plant per year until 2010. Assuming the four planned facilities are all completed in 2004 (or before), and one plant per year is completed through 2010, each of these with a 2 GW capacity, the total nuclear capacity in 2010 would only be 20.75 GW. The goal of 40 GW could only be achieved if the construction schedule is doubled after 2004, or plants of 4 GW are constructed. Logan et al cites a government prediction of 20GW by 2010. That report even considers this goal unlikely, though as seen, it is closer to realistic. *The International Energy Outlook 1998* projects a nuclear capacity of only 11.5 GW by

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185 *Projected Costs of Generating Electricity: Update 1992*, Organisation for Economic Co-operation and Development (Paris: OECD, 1992), 63.

2010.[186] This seems to be a low estimate, probably based only on firm construction plans. Achieving this goal is certainly possible, as it would only require the construction of 2-3 plants between 2005-2010.

For nuclear power to maintain its current 1% share of China's electricity production, a capacity of only 4 GW assuming low growth and 6.8 GW assuming high growth would be required. If the projected capacity of 20.75 GW is achieved, this will leave an excess capacity of 16.75 GW assuming low growth, and an excess of 13.95 under high growth. According to Si Liang, the 40 GW goal was based on a desire to raise nuclear power's contribution to 5%. This would require 20 and 34 GW of capacity for the low and high growth rates, respectively. It is now clear that the first of these is achievable, while the second is doubtful. Therefore if the low growth scenario proves the actual course, then nuclear power will likely assume about a 5% share, while if high growth occurs the contribution will be closer to 3%. This will allow China to forego the use of 40-48 Mtons of coal.[187] In either event, the role of nuclear power will increase, assuming the current growth plans continue.

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[186] "Nuclear Power," in *International Energy Outlook 1998.*

[187] Assuming a capacity factor of 0.8 for nuclear power plants in China. Figure from Jeffrey Logan.

C. RENEWABLE RESOURCES

Most remaining energy sources can be grouped into the category of renewable resources, or simply "renewables." [188] These can be defined as "those resources that, after being used, can be brought back to the original state without human effort."[189] Renewables are most often praised due to their generally benign impact on the environment. A less considered aspect is their contribution to energy security. This can be significant, due to the lack of an external fuel requirement. These sources generally use naturally occurring resources to produce energy, and by definition this supply is generally replenishable, making these power sources able to be "self-contained" within a country's borders.

The most common renewable with applications relevant to power generation is hydropower. This source has moved out of the realm of alternative energy options and has become a traditional power source. Its contributions in China were discussed in the preceding chapter. This chapter instead will focus on the less common options that can provide some potential in China. The most commercially viable options in this category are wind, geothermal, and solar power. By 1995, China's installed capacity for these four was 50 MW, 32 MW, and 6 MW, respectively.[190] These totals show the negligible

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[188] Except where noted, all figures for renewable energy usage and potential in China come from Li Jungfeng, Yih-huei Wan, and James M. Ohi, "Renewable Energy Development in China: Resource Assessment, Technology Status, and Greenhouse Gas Mitigation Potential," *Applied Energy* 56, no. 3-4 (1997): 381-394.

[189] Ih-Fei Liu, 6.

[190] Logan et al, 6.

impact that renewables have had in China's electrical industry. Yet this does not truly capture either the potential of these sources or their true contributions to China's overall energy picture. This will become clear as the specifics of each of these options, as well as biomass and biogas, are explored.

In each case, it will be shown that these sources offer a great deal of potential in China, and in most cases, some of this is already being tapped. However, these sources fit mainly niche markets in remote, rural areas of China, and will contribute little directly to China's national power grid. Their main contributions lie in increasing power in areas not connected to the power grid, therefore preventing more traditional resources from being expended in these areas. Today in China, renewables may reflect a miniscule portion of the commercial electricity picture, but their usage in noncommercial areas amounts to over 300 Mtoe per year. This amount is equal to more than one quarter of the TPES and 47% of all rural energy usage.[191] For this reason, the role of these sources can be substantial, and deserves an examination.

1. Wind Power

Wind power has much untapped theoretical potential in China. This total potential is estimated by the Chinese Academy of Meteorological Science at 3,200 GW, of which 253 GW is deemed technically exploitable.[192] This does not, however, make

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[191] "Headway Made in New, Renewable Energy Development," (Beijing) *Xinhua* (0216, July 16, 1998) FBIS Document ID FTS19980715001652.

[192] As cited in Li, Wan, and Ohi, 383. Logan et al puts the toatl exploitable potential at 1600 GW, but lists the same exploitable amount.

wind power a reliable source for solving large-scale power needs in China. The main difficulty in commercially exploiting this resource is that, simply put, "wind is not a dependable resource."[193] "Wind speed varies naturally, with the hour of the day, the month of the year, altitude, and of course, the site."[194] China's drive for development demands steady, consistent energy. This unpredictable source is unlikely to assume any large-scale role in national power generation.

Further, much of this potential is in remote areas, specifically Inner Mongolia, Xinjiang, and northern Gansu, although there is also great potential in the southeastern offshore islands. This geographical distribution and the wind's inconsistency mean that the most likely uses of wind in China's future are in upgrading electrification in rural areas. Wind can offer a great deal here, as much of the areas with exploitable potential are far removed from the national power grid. Using this—and other renewables—to absorb some of this rural demand, relieves pressure to apply other, more conventional sources to these remote areas, allowing more to go to the developed regions.

At the end of 1995, there were thirteen commercial wind power plants in China ranging in capacity from 55 KW to 12.75 MW. The largest of these is at Dabancheng in Xinjiang. There is one large plant in Guangdong Province, and two moderately sized plants in Inner Mongolia. These are the only plants that have more than ten wind generators. This small number of commercial plants and their limited size reflect the

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[193] Logan et al, 44.

[194] Jorge Gutierrez-Vera, "Renewable in Mexico in the 21st Century," IEEE Power Engineering Review 18, no. 4 (April 1998): 16.

limitations mentioned above. Also, large-scale wind power plants tend to be very costly, averaging about $1000 (U.S.) per KW. This is compared to about $600 per KW for a standard coal plant.[195]

Another factor that relegates wind-power to peripheral areas of China is the inability of Chinese industry to manufacture high capacity wind turbines. As with large nuclear and hydropower turbines, China is forced to import units used for large scale electricity production. Even in the more remote areas of China, the inconsistency of wind makes it a poor choice as the sole electrical generation option. Wind is best used in concert with other renewables or in hybrid systems that couple wind generators with battery storage units and sometimes diesel engines.

China has, however, been a world leader in production of smaller generators and hybrid systems (wind/PV, wind/diesel, or wind/diesel/battery). There are over forty manufacturers of small wind generators in China, 17 of which are in Inner Mongolia. These firms can produce 30,000 generators per year ranging in size from 50 W to 5 KW. This production is geared to service a growing niche market in those areas with exploitable potential. Today there are over 160,000 small wind generators in use in China and this number will likely increase dramatically in rural areas.[196] This number represents a total installed capacity of 17 MW that does not have to be fulfilled by other energy sources.

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[195] Data on costs per KW for various systems is from Logan et al.

[196] "Headway Made in New, Renewable Energy Development."

Despite all of these shortcomings, wind power is rising in importance because of its lack of negative environmental impact. Worldwide demand for wind systems is growing, which is advancing the technology level available, and lowering the costs involved. Capital costs will likely be closer to $750 per KW in the near future, making the systems more attractive. Because of their "green" nature, and potential to raise rural electrification levels, wind systems have been recently targeted by the World Bank and other environmentally conscious organizations for their development projects.

China is one of many recipients of this type of funding, and in March of 1998, Beijing and the World Bank announced plans to develop 190 MW of new wind power at four sites. The planned locations are the Huitengxile field (100 MW) in Inner Mongolia, the Zhangbei field (50 MW) in Hebei, the Pingtan field (20 MW) in Fujian, and the Chongming field (20 MW) in Shanghai.[197] Because of China's turbine manufacturing deficiencies, this new focus on wind power has opened up yet another area of China's energy industry for opportunities for U.S. and other Western firms.[198]

2. Geothermal

Geothermal power can be exploited in either of two ways. Geothermal sources of very high temperature can be used in power generation. Lesser sources can be exploited for direct heating applications. Sources suitable for electric power generation are only

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[197] Logan et al, 45. Also Qi Li, "Large–Scale Wind Power Projects Launched," (Beijing) *Keji Ribao* in Chinese (July 23, 1998), FBIS Document ID FTS19980812000818.

[198] See "U.S. Firms to Explore Wind-Power Resources n Xinjiang," (Beijing) *Xinhua* (0033 GMT, September 2, 1998) FBIS Document ID FTS 19980901001603.

found in two places in China: Tibet and Yunnan (90% of the total is in Tibet[199]). Estimates of the total capacity here exceed 6.7 GW, though only 30 MW has been harnessed so far. 25 MW of this is at the Yangbajin thermal field in Tibet, which supplies between 40 and 60 percent of power to the Lhasa grid, demonstrating the viability of this source. These limited sources will prevent geothermal electricity from assuming a significant role in any province other than Tibet. Like wind power, geothermal's main potential lies in noncommercial applications, through meeting energy needs that would otherwise have to be eventually met by conventional sources.

One example of this is that China currently has 24% of the world total of installed direct geothermal heating systems. Estimated output is about 2,410 MW, and this is projected to grow at 8% per year in the ninth five-year plan. In 1995, direct heating amounted to 5.1 million tce. This is expected to increase to 7.5 million in 2000 and 13.4 million by 2010. These systems are relatively simple to build and operate and have vast potential throughout China, as most provinces have some exploitable geothermal sites.

Even if sites were more plentiful, geothermal electric systems require advanced technology to fully exploit. Although China has been on the cutting edge of its development, further exploitation of these systems would run into limitations due to China's inefficient manufacturing concerns. The small opportunity for applying this technology means that few firms are interested in building the required equipment, and the resulting lack of competition is reflected through poor quality. Also, the limited

[199] Logan et al, 33.

demand for geothermal electric systems precludes economies of scale in the industry, which tends to make the systems quite expensive, creating another barrier to increased usage.

3. Solar

In 1997, the total solar power electrical generation capacity in China was a mere 5.5 MW, only 3 MW of which was from stations connected to the national power grid. As with other renewables, this understates both solar power's current and potential usage in China. These figures represent photo-voltaic (PV) plants only, which are the commercial electric generating application of solar power. A more significant usage of this energy is in solar water heaters. In 1994, China had an installed capacity of 3.3 million m^2 of solar water heaters which saved an estimated 330,000-495,000 tce a year. By the end of 1996, this number had risen to 5 million m^2 (500,000-750,000 tce).[200] China's ninth five-year plan calls for this capacity to increase to 13 million m^2 by 2010. This represents between 4.3 and 6.5 million tce. These systems are going to provide the majority of domestic hot water in rural China's future, especially in areas with inadequate, or no electrification systems. China also uses solar power for a variety of other purposes, including 6 million m^2 of household heating, 150,000 solar stoves, and 40,000 solar greenhouses used in agriculture.[201]

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[200] "Headway Made in New, Renewable Energy Development."

[201] Ibid.

Even the minimal usage of PV plants has potential to increase. China has been developing PV technology since 1958, originally for space applications, and has a moderate level of expertise in producing PV systems. These could be applied in numerous remote areas, as two thirds of China actually receives enough solar insolation to exploit this technology. The best areas for development are in north Ningxia, north Gansu, east Xinjiang west Qinghai, and west Tibet. These areas all receive between 2,800 and 3,300 hours of sunshine annually with total insolation of 6.7-8.4 GJ/m^2.[202] The main limitations in realizing much of this potential are poor quality control in the Chinese PV systems,[203] poor after installation maintenance and, until quite recently, the prohibitively high cost of PV systems.

This has begun to change with recent advances in the industry. These are due to an upsurge of demand world-wide, which is occurring for the same reasons as the increased popularity of wind power. The new interest in using PV technology in residential applications has shifted the paradigm of the PV industry. Previously, the quest in production was to gain the highest energy conversion rate per given size of solar panel. This led to a reliance on silicon based, single crystal cells. These cells are very expensive to produce and consume vast amounts of energy in the manufacturing process.

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202 This is approximately equal to 0.23-0.28 tce per m^2, meaning that every square meter of solar panel could provide as much as 0.28 tce. Conversion factors are from the IEA web page.

203 This is not to imply that the Chinese are not capable of producing these systems. As noted above they possess the technology and have made some good systems. The problem lies primarily in the management of the manufacturing concerns with resulting poor consistency in production of a product that demands precision.

Recently, the goal has shifted to making less expensive cells, which changed the focus to polycrystalline "thin film" cells. Both of these are less efficient than single cell panels, but they are much easier and less expensive to produce. Also, the thin film cells are flexible enough to be installed as a coating on roofing tiles or window panes. These new applications have made single house PV systems financially viable in areas not serviced by traditional electricity. Approximately 40,000 families in China have these systems so far, and a part of the World Bank development initiative mentioned in the discussion of wind power aims to supply these systems to 400,000 herdsman households in northwest China.[204]

4. Biomass/Biogas

The use of wood and other natural products as an energy source is literally as old as fire. This is the simplest application of biomass to solving energy needs—burning wood or other residue for heat. In rural China, that is still how most families heat their homes. Not only wood, but all manner of biomass is collected and burned for energy, including crop residues, animal dung, leaves, dry grasses and sod. This is how many Chinese have lived for centuries, and despite all the strides the PRC has made in its development drive, over 300 million people in China still resort to this energy source to at least partially meet basic needs.

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[204] See Ernesto N. Terrado, "Bringing Renewable Energy Concepts to Market Reality: The Solar Initiative," *IEEE Power Engineering Review* 18, no. 5 (May 1998): 12-16. For a discussion of the type of systems being used in China, see Trish Saywell, "Power to the People," *Far Eastern Economic Review* 161, no. 5 (January 29, 1998): 36.

This massive contribution of biomass is not considered in commercial energy computations like TCEC. Because this fuel comes from sources that are not easily quantified, the true extent of its contribution is difficult to estimate. One attempt using indirect methods of estimating consumption puts the total biomass usage at around 117 mtce.[205] At first glance, this seems like a sensible and benign method of filling rural energy needs. Unfortunately when a country with a population the size of China resorts to burning "everything in sight" to meet basic cooking and heating needs, the amount of materials consumed begins to have negative effects. Some obvious ones are deforestation and soil erosion. A less obvious yet growing problem is that the burning of crop residues instead of plowing them under deprives the soil of needed nutrients and reduces long-term crop yields. This is something that a country with nearly a quarter of the world's population and only 7% of the arable land can hardly afford. A final side effect is increases in GHG emissions from the numerous unfiltered fires.[206]

Yet biomass has promise for the future, because there are more efficient ways of using this resource than simply burning it in household stoves. One option is to collect the mass, reprocess it and burn it in commercial boilers along with coal.[207] This

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[205] Smil, 101-103.

[206] For more on the limitations of biomass fuels, see Smil. Also *Energy in Developing Countries*, 100-104.

[207] For a discussion of this process and other technological renewable applications, see Renewable Energy Technology Characterizations, U.S. Department of Energy, Office of Utility Technologies Topical Report No. TR-109496 (December 1997), Chapter 2, Available [Online]: http://www.eren.doe.gov/utilities/techchar.html.

process—called cofiring—not only results in efficient use of biomass, it can also reduce SO_2 and NO_x emissions 20-40% when compared to a standard coal plant. Unfortunately, while this process has been successfully demonstrated in numerous tests in the U.S., it will be years before the technology is commercially available anywhere, let alone in China.

A more common process, known as biomass gasification, takes the wood and crop residues and converts them into either methanol or ethanol.[208] These gases can be used in a variety of applications, including power generation, cooking, and heating. China has been pursuing this avenue for decades, and today has the largest research and development capacity in the field. As a result of this investment, China is a world leader in the technology, and has over 600 biomass gasifier systems presently installed, primarily in the furniture and timber drying industries. Each of these systems produces about 175 KW of power, although plans are under development to develop large systems capable of producing up to 800 KW. These systems produce power that is used in rural villages not connected to a power grid.

A related process that can be applied on a small scale is anaerobic fermentation or anaerobic digestion. This technique uses animal, human, and plant wastes to produce a mixture of methane and carbon dioxide.[209] This is simply capturing and controlling the

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[208] A thorough review of the biomass gasification process and a review of the various systems used in China (and other developing countries) is presented in *Fueling Development*, 222.227. See also Smil, 104-106.

[209] See *Fueling Development*, 219-222. For a very simplistic review of the biology of the process and sample designs for building a household digester, see David House, *Biogas Handbook* (Culver City, CA: Peace Press, 1981).

natural process of rotting wastes, like that which produces "swamp gas." This is a "low-technology" technique that can done by an individual household to produce gas for cooking, heating, or running a small electric generator. Aside from the energy provided, this process has other benefits. According the U.S. National Academy of Sciences, it is "the simplest and most practical method known for treating human and animal wastes to minimize the public health hazard associated with their handling and disposal."[210] Additionally, the waste product that is left at the completion of the process is a valuable fertilizer.

Because of the simplicity of this process, this technique is already widely used in rural China. By the end of 1994, there were 5.4 million household digesters in use producing 1,270 million m^3 of biogas each year. Additionally, there are over 600 larger installations which process waste from industrial concerns and provide biogas to 84,000 households, and 154 electric power generators with a combined capacity of about 3 MW. While there is still much room for further extension of this technology in China, it will encounter limits due to weather constraints. The digestion process does not occur when the ambient temperature is too low. The relatively warm weather requirement restricts this option to areas in southern China.

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[210] National Academy of Sciences (NAS), *Methane Generation from Human, Animal, and Agricultural Wastes,* Report of the Panel on Methane Generation of the Advisory Committee on Technology Innovation of the Board on Science and Technology for International Development, Commission on International Relations, NAS (Washington, D.C.: National Academy of Sciences, 1977), 4.

VII. OBSTACLES AND OPPORTUNITIES IN CHINA'S ENERGY FUTURE

A. GENERAL OBSTACLES

Meeting growing energy needs on the scope of those occurring in China would be a daunting task in almost any country. In China, it is doubly so, due to a variety of obstacles. Beijing's preference for self-reliance demands that indigenous energy supplies be fully exploited to minimize dependence on imports. As documented in previous chapters, this is not being accomplished. This chapter will begin by examining some of the obstacles preventing China from more fully using its own energy reserves.

The most significant of these is an inadequate infrastructure—primarily transportation, but also electrical—that is greatly overtaxed. Another problem that affects many energy sources is the need for advanced technology and dependable technical manufacturing ability. Related to this, because it makes getting outside assistance difficult, is China's distorted energy market in which domestic oil and gas prices are fixed at artificially low rates. A final obstacle is the need to ensure that any energy source on which China relies is "secure." This requirement limits the amount of resources that China will simply buy on the open market as this route may not be available in times of crisis.

1. Infrastructure Deficiencies

Many of China's possible energy sources cannot be fully exploited due to geography. As stated in China's *Agenda 21*:

> The distribution of China's energy resources do not mesh with the distribution of economic activities, since nearly 80% of energy reserves are located in the western and northern parts of the country, while 60% of energy is consumed by the economically advanced southeastern part of the country.[211]

This can be overcome by either of two ways. For solid fuels, such as coal or oil, the fuel can be transported to the source of demand and then converted to electricity. The other method, which can be applied to virtually any energy source, is to construct a power plant near the energy source, then transmit electricity to the source of demand. Both of these options are severely limited by China's aging infrastructure. No country in history has undergone the sustained level of growth that China has seen over the last twenty years. A lesson to be learned from China's experience is the importance of infrastructure investment keeping pace with growth. The failure of this in China has resulted in severe limitations on distribution of all goods in the country, and energy is just one area that feels the pinch.

a) Transportation

The largest deficiency in China's infrastructure is its antiquated transportation system. Due to the geographical mismatch of energy supply and demand, transportation is key to meeting energy needs throughout the country. Today, 42% of China's rail capacity is dedicated to transporting coal, with approximately 650 million tons (Mtons) moved annually.[212] In recent years, a lack of sufficient rail assets has meant

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211 "Sustainable Energy Production and Consumption," in *Agenda 21*, Chapter 13, 3.

212 McCreary et al, II-31.

vast quantities of coal go into storage at mine sites awaiting transit. The U.S. DOE estimates that 80 Mtons are currently awaiting transit with another 20 Mtons added annually. On the other end of the rail lines, Chinese industries have occasionally had to slow production due to coal shortages.[213] Also, as mentioned earlier, a great deal of coal is used inappropriately throughout China, directly due to a rail shortage.

Coal is not the only source of energy effected by this shortage. The impact of the inadequate rail service connecting Xinjiang Province with central China on oil production in the Tarim Basin has already been discussed. It is only now able to keep up with current demand, with 60-70% of all rail traffic travelling in or out of Xinjiang carrying oil or related equipment. If the Tarim Basin ever proves to have the level of reserves that China hopes (and desperately needs), this line will be completely overwhelmed.

The majority of oil, however, travels not by rail, but pipeline. China's existing system of pipelines, which comprises over 10,000 km of pipe, was sufficient to distribute the relatively static oil production from the northeastern oil fields. When oil production began to increase in Xinjiang, and the limits of the rail system became apparent, it was soon realized that the pipeline system was out of date. A first step was taken in 1994 when construction began on a 1000 km pipeline to connect Xinjiang to

[213] As mentioned in the section on coal supply, the country adapted to this situation through a variety of means, largely the creation of thousands of small coal mines. This has led to an overall surplus of coal in China, and exacerbated the improper usage of high grade ores.

Sichuan to help overcome the dificiency. This will allow production in the Tarim to further increase, though this pipeline will likely rapidly reach maximum capacity.

China's deficient railway has led to increased reliance on imports, even for commodities that China can produce internally. The exchange of oil imports and exports discussed in an earlier chapter is one example of this phenomenon. Many high-demand regions in southeastern China find it cheaper and more reliable to import oil and coal than to depend on the country's indigenous supply. If China were to build more natural gas power plants, particularly in these same provinces, liquid natural gas (LNG) imports would be the only short-term way to support them. This is one of the factors that keeps China from switching to gas.

Aware of these problems, the Chinese have been building railways at a furious pace, laying 6000 km of new line, 3500 km of which was double track, between 1990-1995. This rapid increase was possible because it was largely replacing or upgrading antiquated track. Laying new track in unprepared terrain will be significantly more difficult and expensive. Yet, the Chinese have shown the capacity for building as much as 3000-4000 km of new track a year at a cost of approximately $3.4 -$4.6 billion (U.S.). The ninth five-year plan allocates $34 billion over five years to the railways, with $24 billion of that for track construction, indicating the importance of the railways to China's leaders. Despite this level of commitment, it will be several years before China catches up with current nation-wide demand, let alone future needs. In addition to the

shortage of rail, China is also woefully short on rolling stock (both engines and cars), and much of what they have is antiquated (some engines are still coal-fired).

Rail is the primary freight mover for energy related fuels, but road transportation is also an enabler of economic development. As China grows, "highways and roads are increasingly important for freight transport, especially for short-distance transport of goods. Its share in the total freight volume increased from 3% in 1978 to 15% in 1993."[214] Road transport is also gaining in importance as a passenger mover, relieving China's rail system of some of this burden. A sign of this, came in 1990, when for the first time, highways moved more people than railways.

The growing number of cars and trucks in China has already been discussed, but road construction is not keeping pace. For road transport to relieve any significant strain from the railways, the level of investment must increase. Some regions are more aware of this need than others, and Joyce Man demonstrated that there is a positive correlation between each region's level of investment and GDP growth.[215] Man summarized the need well by saying:

> As China's transportation infrastructure lags behind all developed countries, a much greater investment effort will be necessary in the transport sector to catch up with the backlog of present needs as well as accommodate a sharp increase in demand. Failure to do so may stifle economic growth.[216]

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[214] Joyce Y. Man, "Transportation Infrastructure and Regional Development in China," *International Journal of Public Administration* 21, no. 9 (1998): 1307-1321, specifically, 1313.

[215] Ibid.

[216] Ibid, 1318.

Some of these lessons appear to be finding an understanding ear with Zhu Rongji. He seems to have set out to turn this challenge into an opportunity by using increased infrastructure investment to help spur the economy in the fourth quarter of 1998 back onto the path towards 8% growth.[217] This is a step in the right direction, but must be sustained over the long haul, and not be seen as a gimmick to boost the economy.[218]

One last transportation infrastructure shortage affecting China's energy future is a shortage of adequate port facilities to handle coal exports or gas and oil imports. This does not directly effect the exploitation of China's indigenous energy supplies so a detailed analysis will be omitted. It is, however, a glaring obstacle to increasing distribution along the coast or to bringing in the increased amounts of oil that will be needed, or LNG if that route is pursued. Most of China's ports are all working at maximum capacity, primarily as freight export ports, and though construction is proceeding all over the coast, it is having difficulty keeping up with demand. There are numerous upgrades planned, but they will likely be inadequate.[219]

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217 "China Economy: Plan to Raise $24.4bn for Infrastructure," *The Economist Intelligence Unit* (September 30, 1998), Available [Online]: Mead LEXIS/NEXIS/ASIAPC/CURNWS/China and transportation [October 14, 1998]; "China-Infrastructure Investment Helps Fulfill Growth Goal," *China Daily*, FT Asia Intelligence Wire (October 12, 1998), Available [Online]: Mead LEXIS/NEXIS/ASIAPC/CURNWS/China and transportation [October 14, 1998]; "China-Investment in Transportation Infrastructure to Rise," *Asiainfo Daily China News*, FT Asia Intelligence Wire (October 6, 1998), Available [Online]: Mead LEXIS/NEXIS/ASIAPC/CURNWS/China and transportation [October 14, 1998].

218 The likely success of this measure in boosting the economy is suspect at best. See "China-Consumption Decisive, Too," *China Daily*, FT Asia Intelligence Wire (October 8, 1998), Available [Online]: Mead LEXIS/NEXIS/ASIAPC/CURNWS/China and transportation [October 14, 1998].

219 Data on China's port capacities and usage can be found in *China Statistical Yearbook 1995* (Beijing: State Statistical Bureau of the People's Republic of China, August 1995), 484-485. For some examples of expansion plans, see "China Project: Qinzhou Port to Build 10 Oil/Gas Wharves," Nationwide Financial News, *Asia Pulse* (August 19, 1998); "China Qingdao Port to Handle 100 Million Tons of Cargo

b) China's Electricity Infrastructure

An alternative open to many countries for overcoming transportation deficiencies would be to emphasize mine-mouth construction of power plants to situate power plants at the fuel source, thereby eliminating the transportation need. From this arrangement, power can be transmitted to wherever it is needed. While China is pursuing this route to alleviate some of the burden on the rail system, the capacity that can be shifted will reach another limit due to the country's poor electrical transmission infrastructure. This route may solve some regional problems, but it is not a viable option for absorbing greatly increased national demand, because the country has no interconnected national power grid. The present electrical distribution system consists of six regional power grids and seven provincial grids.[220] There are some interconnections between some of these, but only for emergency power transfer. These are incapable of supporting any massive redistribution of power.

This situation is changing slowly, but it will be many years before this obstacle is overcome. In 1990, there was approximately $808 million (U.S.) spent on power grid construction. Since then, between 15 and 25 percent of the annual

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per Year," *China Business Information Network*, FT Asia Intelligence Wire (July 10, 1998), Available [Online]: Mead LEXIS/NEXIS/ASIAPC/ CURNWS/China and shipping [October 15, 1998]; "Business in Asia Today-July 17, 1998," *Asia Pulse* (July 17, 1998). For a discussion of one of the barriers to further development of this sector, see Wong Joon San, "Mainland Needs More Foreign Money to Add Capacity, Says Researcher; Ports Seek Overseas Investment," *South China Morning Post*, (June 22, 1998): Freight and Shipping Post, 1, Available [Online]: Mead LEXIS/NEXIS/ASIAPC/CURNWS/ China and shipping [October 15, 1998].

220 "Fueling Development," 187.

expenditures on the electrical sector have been for grid improvements. China's goal is to have the entire system interconnected by 2020. One reason for this delay is that the current plan to integrate the grids relies on the completion of the Three Gorges Dam to power much of central China. Until this plan is completed, regional power shortages will continue to be routine, and it will not be feasible to fully exploit energy opportunities in remote areas. The challenge for Beijing is meeting needs in high demand areas until then. But completion of these plans will still not mean that every corner of China will have access to grid supplied power. There will still be isolated pockets of the country that must turn to local solutions.

Another key part of China's electricity infrastructure that has not really been addressed in this thesis is the rapid rate of construction of new power plants. The recent growth has been nothing short of phenomenal. While the energy sector has grown at an average of 3-5% over the last two decades, the power sector has averaged 8% growth. China has increased electrical generation capacity an average of 15 GW each year. This is equivalent to building a new 565 MW power plant every two weeks.[221]

This has been possible because China opened the market for limited participation by foreign companies and investors. This has increased the capital available and accelerated the rate of construction. This practice is continuing with the expectation that roughly 20% of the $8 bn (U.S.) needed each year to finance future construction will

[221] Logan et al, 2.

come from outside sources.[222] Construction will continue in the coming years, and this will not be a constraining factor on China's energy. Therefore, a detailed analysis of the financing involved and cost-benefit analysis of the various types of plants will not be completed here.[223] The important factor for this thesis is that the decision as to what type of fuel these plants will use, will be driven by security concerns more than economic ones. Many analysts point out the benefits of natural gas or increased usage of renewables as either less expensive, or more environmentally sound alternatives to China's current energy use patterns. These arguments, while persuasive, neglect the all important security concern. The prices China is willing to pay for oil and gas reserves show that economic arguments are less important to Beijing than security concerns.[224] Choices made on this basis will have more to do with whether or not China can meet future energy needs than with the relative costs of various fuels.

2. Energy Prices as a Barrier to Development

One obvious reminder of China's long standing planned economy is the existence of price subsidies and artificially fixed prices in some sectors. The reforms begun in 1978 have gradually adjusted many prices to market levels, but China still feels the need

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[222] This dependence on outside assistance has been mentioned. It can be reconciled with the fear of outside influence in that China realizes that once the plants are built, the country will not lose them should the international situation deteriorate. This is not likely a supply contract that could be suspended.

[223] An excellent review of the comparative costs of various electricity options open to China is available in Logan et al.

[224] Refer back to Rashid and Saywell for a review of China's aggressive bidding practices.

to "protect" key industries. The energy sector is one notable example. As discussed, China needs to further develop its energy industry to fully exploit indigenous resources. It has viewed artificially set prices for oil and gas as keys to allowing this industry to grow. The practice is also seen as supporting other state owned enterprises (SOE's) by providing energy at below market prices. This practice does not end up helping the energy industry, and it is in fact quite counterproductive. As the World Bank stated in 1993:

> The current price system interferes with balanced sectoral development by discouraging investment in precisely the designated priority sectors in China's industrial policy. State-set prices prevent those sectors from accumulating their own resources, forcing planners to counteract this through administratively arranged transfers.[225]

The effect of this price fixing is most easily seen in the natural gas industry. This subject has already been touched on, but the basic problem is that the internal price of gas is fixed too low to provide much incentive for desperately needed outside investment in the industry. A further effect is that the industry ends up subsidizing other under-performing SOE's by selling them gas or oil at unreasonably low prices, thus depriving the oil and gas industry of capital to finance its own expansion. These two effects together cause under investment in the industry, which results in production growth that is inadequate to support demand.[226]

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225 The World Bank, *China: The Achievement and Challenge of Price Reform* (Washington, D.C.: The World Bank, March 1993), 10.

226 See Logan and Chandler, "Natural Gas Gains Momentum;" Logan and Chandler, "Incentives Needed for Foreign Participation in China's Natural Gas Sector;" Paik and Quan; "China's Gas Quest;" "China: It Takes Just One Spark;" and David Blumenthal and Gary Susser, "Fuel for the Next Century," *China Business Review* (July-August 1998): 393-394.

This has the added consequence of limiting development in other areas of the energy sectors aside from oil and gas. The limits of China's oil and gas production make it desirable to encourage development in alternative power sources, many of which have been discussed. This is, however, discouraged by the low oil and gas prices, as it is not economically viable to invest in more expensive resources. Tragically, it is only through further investment in these industries that their costs will decrease to the point of being competitive options for large-scale applications.[227]

Beijing is finally recognizing the negative impact of the price fixing policy, and is taking steps to correct it—but only for oil and oil products. Starting in June 1998, the government implemented a new pricing system that is designed to gradually bring prices somewhat in line with international market prices. The new system is extremely complex and it is too early to assess its success.[228] Unfortunately, this will not completely solve the oil industry's problems.

One obstacle that will remain is that the current international oil prices are near historic lows. When oil can be obtained cheaply from the open market, it is difficult to encourage investment in expensive exploration of areas like the Tarim Basin or the South China Sea. This situation is beyond Beijing's control, however, and the recent reforms are at least a sign of progress. There are no such signs for natural gas. This is the

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[227] For a discussion of the effect of low oil and gas prices on the development of renewable technology, see Li, Wan, and Ohi, 393-394.

[228] A review of the new pricing system can be found in "China's Oil Price Reforms a Major Step in Deregulating its Petroleum Sector," *Oil and Gas Journal* 96, no. 32 (August 10, 1998): 46-48.

industry that most desperately needs reform to spur rapid growth. This fuel has the most untapped potential in China, and Beijing is squandering the opportunity to more fully reform its energy sector.

3. Technology Limitations

China's extreme autarky movements of the 1960's and 1970's left China's energy industry decades behind the developed world. This and a variety of supply issues, already discussed, have led China's power generation sector to focus on tried and true, simple technologies fired mostly by coal. Reform in this area has been slow.

The situation outlined in this thesis makes it desirable for China to diversify and modernize its power industry by building larger, more efficient plants. China's lack of experience in this field hampers the country's ability to fully exploit new opportunities. In most areas, China has developed a reasonable level of technical expertise, but this is not always sufficient. The most notable example is the previously mentioned inability of the country's SOE's to manufacture high capacity (greater than 600 MW) turbines for use in either thermal, nuclear, hydropower, or wind power plants. Those items that the country can produce are often done so with poor quality control and management, thus limiting the dependability of the industry. This is most pronounced in those areas that require "state-of-the-art" technology, like renewables.[229]

China's solution has been the same across many sectors, and the energy sector is just one of many to tackle this problem. The path chosen is to embark on numerous

[229] Discussed in Li, Wan, and Ohi.

forms of joint ventures to obtain needed items or effect technology transfers. China's huge market provides irresistible incentive for countless countries' industries. Most are quite eager to provide whatever technical expertise is desired to carve out a niche in China's market. U.S. policies that limit opportunities for U.S. firms (notably in the civilian nuclear industry, though this could be changing if the US-China Nuclear Cooperation Agreement ever goes into effect) do not restrain China's options, it merely forces China to look to other countries for needed materials and technology.[230] The only ones punished by such measures are U.S. companies.

4. Security First

The final obstacle that will be addressed is China's emphasis on security above all other considerations. This has been touched on throughout this thesis, and is in fact central to the main argument of this work. Therefore, extensive elaboration is not required. It is necessary here to simply highlight the role of security as an obstacle to development.

Threads of this have been interwoven into each of the energy supply sections. China's emphasis on security in its supply over other factors such as market availability, affordability, or environmental impact, has prevented China's energy industry from achieving the maximum possible growth. The most notable example is the vast potential for natural gas power in China's coastal regions. LNG imports could be readily obtained

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[230] For more on the debate surrounding this agreement, see Congress, House, , *Implementation of the U.S.-China Nuclear Cooperation Agreement: Whose Interests are Served?*

on the open market in ample quantities and at an affordable price to meet China's power needs.[231] But this is a path not chosen, because fundamentally, China's "leaders are uneasy about committing China to a fuel that must be imported."[232] They are unhappy about having to rely on imports for oil, but pragmatic enough to know this is unavoidable. The country has no real reliance on natural gas, so if no dependence is developed, this is one area where the need to import can be prevented.

The irony of this policy is that this focus on security is quite likely to undermine China's security, rather than help ensure it. The effect of this approach is insufficient demand to spur the internal development that could boost China's gas industry. This has the end result of removing one strong contender for guaranteeing China has a dependable supply of energy. This is where U.S. policy could play a role. It is imperative that the U.S. acknowledge and address legitimate Chinese security needs and stop trying to impose its will on Beijing. While true reliance on market solutions might solve China's energy woes, this will not occur until China's leaders feel secure in such action.

B. OPPORTUNITIES

China's present energy situation can be seen as a dark cloud on the horizon, or it can be viewed in a more positive light. It is clear that China cannot build its energy industry as an exact copy of a Western developed country, because the country's resource

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231 See "China: It Takes Just One Spark;" and Logan and Chandler, "Incentives Needed for Foreign Participation in China's Natural Gas Sector."

232 "China: It Takes Just One Spark."

base does not favor such a model. This is in one sense convenient, because China does not want to be seen as directly copying any other country. China has the opportunity to set a new example for development by pursuing different options. The country is already doing this to the extent that it relies on less traditional power sources in rural areas. The danger is that the country may see this as a liability and not as a strength.

To at least some extent, Beijing seems to be avoiding this trap. The ultimate combination of energy sources in China's future will not follow any modern Western model, nor will it follow any traditional Asian one. One thing that is certain is that the end result will be uniquely Chinese. But to get there, the above mentioned obstacles must be surmounted. The following sections will look at how this will be accomplished, as well as some other options that should be considered.

1. Oil Imports

The net result of China's energy supply situation is that most needs can be met out of indigenous sources, except for the rising demand for oil, and to a lesser extent, natural gas. China's indigenous production simply cannot keep pace with the growing demand. As shown in Chapter V, the annual gap between demand and supply will likely amount to as much as 75 Mtons assuming low growth, and as much as 266 Mtons under high growth. This can be put into context, by noting that China was a net exporter of crude oil until 1996, and in that year, the net imports were only 2.3 Mtons.[233] Filling this gap will

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[233] Total imports were 22.62 Mtons (see Table. 4), and total exports were 20.33 Mtons. "Petroleum Imports and Exports," *China Petroleum News.*

mean increasing imports at the rate of over 5 Mtons annually under low growth, and almost 19 Mtons annually under high growth. The total increase in net imports between 1995 and 1996 was only 4 Mtons. This should indicate the magnitude of required future oil imports. Refer to Table 6. as the following sections examine possible sources for China's future oil demand.

Country	1995	1996	Change	1996%
Indonesia	5278.8	6296.1	1017.3	27.8%
Vietnam	761.1	1006.9	245.8	4.5%
Malaysia	588.4	219.3	-369.1	1.0%
Papua New Guinea	334.8	471.4	136.6	2.1%
Australia	64.4	188.2	123.8	0.8%
Pakistan	49.4	0.0	-49.4	0.0%
Others	4.3	33.1	28.8	0.1%
Subtotal: Asia-Pacific	**7081.2**	**8215.0**	**1133.8**	**36.3%**
Oman	3653.2	5654.6	2001.4	25.0%
Yemen	2473.2	3765.7	1292.5	16.6%
Iran	931.2	2311.1	1379.9	10.2%
UAE	367.8	0.0	-367.8	0.0%
Saudi Arabia	338.6	230.6	-108.0	1.0%
Subtotal: Middle East	**7764.0**	**11962.0**	**4198.0**	**52.9%**
Angola	998.9	1662.4	663.5	7.4%
Nigeria	390.0	0.0	-390.0	0.0%
Libya	207.7	139.1	-68.6	0.6%
Algeria	130.4	0.0	-130.4	0.0%
Gabon	86.8	0.0	-86.8	0.0%
Others	25.6	125.5	99.9	0.6%
Subtotal: Western Africa	**1839.4**	**1927.0**	**87.6**	**8.5%**
Other Regions	400.8	512.9	112.1	2.3%
Total	**17085.4**	**22616.9**	**5531.5**	**100.0%**

Table 6. China's Oil Imports 1995-1996 (thousands of tons) [234]

[234] Adapted from "Petroleum Imports and Exports."

a) Indonesia

China's traditional oil suppliers were its neighbors in Asia, principally Indonesia. Today, that is the only country outside of the Middle East that currently supplies China with quantities of oil large enough to indicate any capacity to absorb some of the future demand. A member of OPEC, Indonesia is the largest oil producer in Asia with estimated maximum annual production around 15 million barrels per day (bbl/d).[235] That country's indigenous consumption is approximately 845,000 bbl/d leaving roughly 655,000 bbl/d available for export. Oil shipped to China currently amounts to almost 130,000 bbl/d, or approximately 19% of this total.[236] If Indonesia were to supply the entire 5 Mtons additional required for the first year, the total exports to China would amount to 75% of Indonesia's total. Beyond the first year, no more could be provided.

Further, it is doubtful that anywhere near that total would be made available. A commitment to China on this scale would require Indonesia to virtually abandon all of the country's other oil customers. It is unlikely that Indonesia would allow itself to be that closely tied to China. This type of relationship might have been thinkable under President Suharto, but President Habibie has made it clear that Chinese will receive no special treatment under his administration.[237]

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[235] Information on Indonesia's oil industry is from "Indonesia Country Analysis Brief," U.S. EIA (March 1998): 9, available [Online]: http://www.eia.doe.gov/emeu/cabs/indonesa.html. [August 6, 1998]

[236] 1 ton=0.02031 barrels of oil per day. Conversion factor from "Glossary of Industry Terms," Shell Oil Company, available [Online]: http://www.shell.com/h/h9.html. [November 11, 1998]

[237] Ethnic Chinese in Indonesia held a privileged position during the Suharto years, during which time they amassed wealth far in excess of what their numbers would lead one to expect. These Chinese were the

b) Middle East

The most obvious source for meeting oil demand on the scale facing China, is the Middle East. That region's vast oil and gas reserves made it a mainstay of U.S. oil supplies for decades. This began to change as the political situation in the region began to threaten the predictability of oil from the region. In response to events in Iran, Iraq, and other areas, the U.S. gradually shifted its dependence away from Persian Gulf oil. Today, though the U.S. is dependent on oil for 40% of its primary energy needs, and half of that is from imports, America is the destination for only 10% of the region's oil exports.[238] However, 85% of the Gulf's oil goes to allies of the U.S. in Europe and Japan.[239] Accordingly, the "United States has enduring interests in...maintaining the free flow of oil [from the Persian Gulf] at reasonable prices."[240]

The U.S. commitment to the region has been demonstrated numerous times, and is being reinforced even today. This level of U.S. influence in the Persian Gulf has meant that China would rather not become heavily dependent on oil from this source. There is the fear in Beijing that if relations with the U.S. were to deteriorate, the U.S. "could use its dominant naval presence in the Gulf to cut Chinese oil supplies as a means

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subject of much animosity and violence during the May 1998 riots, and Habibie has said that the Chinese will no longer be protected and must fend for themselves. Considering this treatment of ethnic Chinese who are actually Indonesian citizens, it is doubtful that Habibie will devote his country to serving the PRC.

[238] *A National Security Strategy for a New Century*, 54.

[239] Ibid.

[240] Ibid, 51.

of pressuring the PRC."[241] According to John Calabrese, the Chinese view U.S. military involvement in the Gulf as "interference," and they suspect the U.S. of wanting to dominate the region as a means of exercising control over the Gulf's resources.[242] The Chinese would like to see countries in the region "friendly to China and not amenable to directives from China's enemies," whoever they may turn out to be.[243]

Nevertheless, Beijing is becoming more pragmatic in its foreign relations, and China's leaders realize that the scope of their growing need for oil means that a large portion of future imports must come from the Middle East. This is due to the region's large proven reserves, idle capacity, and relatively low development and production costs.[244] Faced with this reality, China has gradually increased its involvement in the region over the last decade.[245]

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241 Jonathan Rynhold, "China's Cautious New Pragmatism in the Middle East," *Survival* 38, no. 3 (Autumn 1996): 102-116, specifically, 110.

242 John Calabrese, "China and the Persian Gulf: Energy and Security," *Middle East Journal* 52, no.3 (Summer 1998): 351-366, specifically 354.

243 This is labeled as the basic Chinese goal in the Middle East in Lillian Craig Harris, "Myth and Reality in China's Relations with the Middle East," in Robinson and Shambaugh, 322-347, specifically 327. Harris goes on to say that all other Chinese goals in the Middle East derive from this. The second premise of China's actions in the region is that China desires "a Middle East free of external intervention, a region which settles its difficulties internally....Third, China uses its relationships with Middle Eastern states and organizations to enhance its authority in the developing world and, during the last decade, to further its internal 'modernization' ambitions."

244 Calabrese, 356.

245 Calabrese provides an excellent review of China's increasing influence in the Persian Gulf, both politically and economically. Most of the details in this section are from that source.

Prior to the Gulf War, China had established relations with all of the Gulf countries (relations with Saudi Arabia were just established in 1990), and was becoming increasingly involved in the Middle East peace process as a means to extend its influence. The Gulf War left China in a difficult position, as the country was poised to profit from oil in Iraq. Ultimately, China acquiesced in UN action in Iraq, though it fell short of total endorsement, which led to the suspension of Kuwaiti development funds bound for China. After the War, China gradually regained her position through such actions as the reconstruction of a Kuwaiti oil refinery. In 1993, China began importing oil from Kuwait for the first time, and agreed to triple its imports from Saudi Arabia.

By 1996, over half of China's total oil imports came from the region (see Table 6.). This is expanding, as Beijing is entering into numerous deals for oil purchases, joint oil production agreements, pipeline construction plans, and refinery supply arrangements with Iran, Kuwait, Saudi Arabia, Oman, and the United Arab Emirates. The Gulf countries recognize the vast potential in China's market, and are scrambling to obtain their share. Some examples include the Kuwait Petroleum Company (KPC) owning a 14.7% share of the Yacheng-13 gas field, and Saudi Arabian ARAMCO's participation as the largest shareholder in the Thalin Refinery in China, as well as plans to build a new refinery in Qingdao. Furthermore, China has become the leading customer of both Kuwaiti and Saudi Arabian fertilizers.

The reason for concern in the U.S. is that China does not share the U.S. view of Iran and Iraq as rogue nations, and is willing to deal with them as much as the

other Gulf states. China already imports oil from Iran, and a planned pipeline from Kazakhstan includes a 1000 kilometer stretch that connects the Chinese controlled Uzen oil field in Kazakhstan to the Persian Gulf where oil can be shipped back to China. This route travels directly through Iran, providing that nation with increased access to world markets. In Iraq, China has laid the groundwork to develop the Ahdab oilfield, and is positioned to begin production as soon as UN sanctions are lifted.

As the U.S. stake in Gulf oil decreases and China's increases, the stage is set for competing loyalties among the Gulf nations. If this trend continues, it might become increasingly difficult for the U.S. to obtain regional support for actions against Iran and Iraq, especially if China does not support such moves. While the U.S. would like to isolate these countries, both diplomatically and economically, the size of the Chinese market makes the latter difficult to do without Chinese support, and China's veto power on the UN Security Council makes the former somewhat problematic. It is unlikely that Beijing would eagerly agree to any further sanctions on either of these two nations when China is poised to profit from their reentering the international community. Such a competition of wills would leave the Gulf States in a difficult position, and the result may not always be what the U.S. would like.

c) Central Asia

In its drive to diversify supply and minimize the negative aspects of expanding dependence on current suppliers, China has been looking to new areas for oil and gas. The most promising of these is Central Asia. This area, together with the

Transcaucasia region across the Caspian Sea, contains almost 4% of the world's proven oil reserves and almost 6% of the gas reserves.[246] This represents vast potential that has only begun to be tapped with the dissolution of the Soviet Union.

Yet, while the region is rich in potential, "economic dislocations caused by the collapse of the Soviet era logistical relations and the transition to a market economy have...left governments with insufficient funds to develop these resources."[247] The largest barrier to development is the lack of any export transportation infrastructure. The few pipelines that do exist in the region were built by the Soviet Union to serve Soviet markets. Russia's current financial troubles, and the desire to promote its own oil and gas industries means that this route has been essentially closed, at least as an export route. Some oil and gas still flows, but only to Russia, and not for sale at market prices.[248]

This situation presented the perfect opportunity for China. The Central Asian Republics have oil and gas, which they desperately need to bring to market to provide capital to develop their countries. China is a rapidly developing country, which is thirsty for oil and gas. This has led to a marriage of convenience between China and Kazakhstan for oil, and between China and Turkmenistan for gas. In 1997, China's CNPC outbid several Western competitors and obtained exclusive development rights to

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[246] "Caspian Sea Overview," IEA, Available [Online]: http://www.iea.org/pubs/studies/files/caspian/overview.htm: 1-2. [October 27, 1998]

[247] Ibid, 5.

[248] For more on the Caspian situation, see "Caspian Sea Overview." Also James P. Dorian et al, "Energy Investment and Trade Opportunities Emerging in Central Asia, Northwest China," *Oil and Gas Journal* 96, no. 24 (June 15, 1998): 48-60; and *International Energy Outlook 1998*, Appendix C.

the Uzen oil field and a major position in the Atyrau oil field, both in western Kazakhstan. The first shipment of Kazakh oil reached China's Xinjiang Province via rail on October 21, 1997.[249] As already outlined, China's rail system is inadequate to support any huge influx of oil shipments through this region. Therefore, this system cannot be the ultimate method for bringing this oil to China's markets. There are two viable options: transport the oil by ship, or construct new pipelines.

Transport by ship is a traditional method, and one which China will use to some extent. The difficulty with this option is that to simply bring Kazakh oil to a viable seaport will still require some pipeline construction, either to the Black Sea or the Persian Gulf. The U.S. and other Western nations are backing the Black Sea option as this will provide a method for bringing the oil to European and American markets. China prefers the Persian Gulf option as this is much closer to China. The Black Sea option is the plan put forward by the Caspian Pipeline Consortium (CPC) and backed by most countries in the region.[250] This travels overland to the Russian port of Novorossiisk. Kazakhstan prefers other alternatives, because after nearly 75 years of Soviet control, the country wishes to reduce dependence on Russia.[251] China answered Kazkhstan's fears by

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[249] Dorian et al, 56.

[250] For more on the various pipeline proposals in the region, see "Caspian Sea Overview," 9-13; Dorian et al, 57-59; Elshan Alekberov, "Despite Political Obstacles, Energy Work Progresses Around Caspian Sea," *Oil and Gas Journal* 96, no. 24 (June 15, 1998): 38-47, specifically 40-41; and *International Energy Outlook 1998*, Appendix C.

[251] Dilip Hiro, "Kazakhstan/China: Border Pact Removes Last Hurdle to New Ties," Inter Press Service (July 7, 1998), Available [Online]: Mead LEXIS/NEXIS/ASIAPC/CURNWS/China and Kakhstan. [October 15, 1998]

proposing two pipelines. The first will bring Uzen oil to the Persian Gulf via Iran, and the second will be a direct line to Xinjiang. These are depicted in Figure 4.

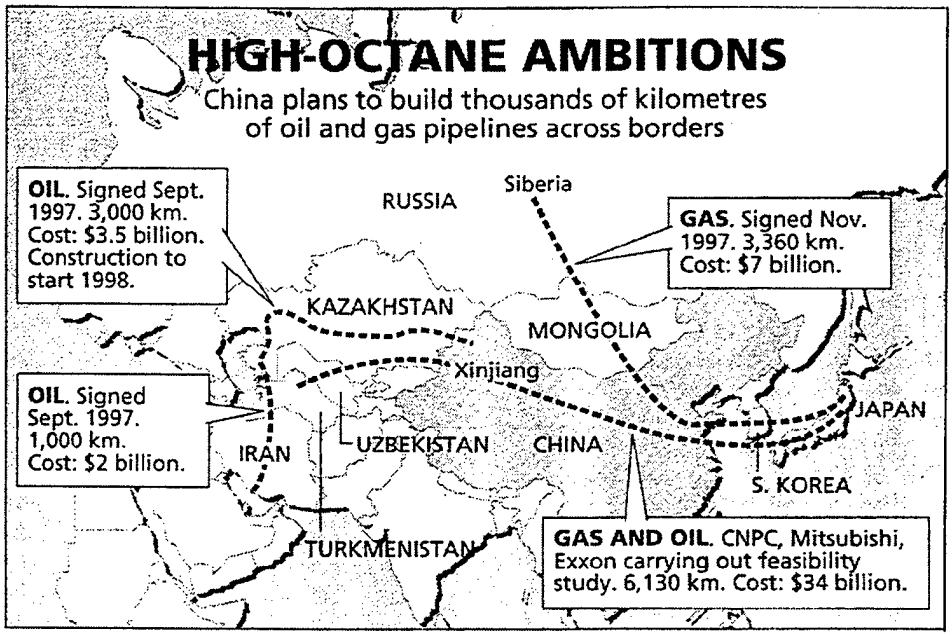

Figure 4. China's Pipeline Plans[249]

The route through Iran was discussed in the section on the Middle East. The overland route to China seems quite positive, and can be seen as reasonably secure to China. However, as mentioned earlier in this chapter, the rail and pipeline infrastructure connecting Xinjiang to the rest of China cannot support drastic increases in volume. This is adding further incentive to upgrade the pipeline system throughout China. This is an enormous undertaking, which Beijing finally seems determined to start. The first major step is a plan to further enhance the scope of the proposed pipeline to Xinjiang, increasing the total pipe laid to 4,200 km.[250] This project, once completed, should be sufficient to

[249] From Rashid and Saywell, 48.

[250] "China to Lay $2.4 bln East-West Oil Pipeline," *Asia Pulse* (November 2, 1998).

meet demand well into the next century. A similar 6,700 km pipeline is planned to bring gas from Turkmenistan to China (also depicted in Figure 4.), though this plan is not as well developed.[254]

d) Russia

This massive cooperation between China and the Central Asian Republics is making Moscow nervous. Despite these countries recently becoming independent states, Russia still considers the region part of its "sphere of influence" and does not like to see its former "protectorates" developing strong alliances and economic independence along Russia's southern border.[255] China is aware of Russian concerns and is being quite proactive in addressing them. This is another display of pragmatism, because Beijing recognizes that Russia, too, has vast oil and gas potential.

That potential was one of the motives that drove Beijing and Moscow to declare a strategic partnership in April 1996.[256] Despite conflicting goals in Central Asia, Russia and China need each other almost as badly as China and the Central Asian Republics. In some ways, Russia is an even better source of gas. Though Turkmenistan

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254 Andrey Kirillov, "Turkment President Urges China to Exploit Oil Deposits," *ITAR-TASS* (1641 GMT, September 2, 1998), FBIS Document ID FTS199809034001285.

255 This is discussed in Rashid and Saywell, but is a recurring theme, raised recently in Christopher Bluth, "Russia and China Consolidate Their New Strategic Partnership," *Jane's Intelligence Review* 10, no. 8 (August 1, 1998), Jane's Information Group Limited: 8. This article highlights commonalities between Russia and China, but the tension over China's involvement in Central Asia is looked upon as a "potential source of conflict."

256 Bluth.

has proven gas reserves of over 100 tcf, this is compared to Russia's proven reserves of 1,700 tcf.[257] Turkmenistan's estimated gas production in 1996 was only 1.31 tcf, though the country has demonstrated potential to produce almost 3 tcf per year.[258] This reduced level is due to decreased demand from Russia. Yet, these numbers are compared to Russia's estimated 1997 production of 20.2 tcf.

To tap into this potential, China has proposed a pipeline from Siberia to China's northeastern provinces, with possible extensions to service Japan and Korea (See Figure 4.).[259] This pipeline would only need to be approximately 1000 km to reach China's markets, making this option easier and less expensive to construct, with a greater potential for gas shipments. This is not viewed as an alternative by Beijing, but rather a supplement to other plans. China is pursuing many options simultaneously to further diversify its supplies. This is one large step towards ensuring supply.

2. Joint Ventures and Overseas Acquisitions

To help assuage security concerns, Beijing has taken a new approach to obtaining some of its oil from abroad. Rather than rely on purchase agreements, China has become very aggressive in recent years about actually acquiring oil reserves overseas. CNPC has

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[257] The abbreviation tcf is trillion cubic feet. 1 cubic meter is equal to 37.3 cubic feet (Shell Oil Company web page). These numbers are from the Turkmenistan and Russia Country Analysis Briefs of the U.S. EIA, Available [Online]: http://www.eia.doe.gov/emeu/cabs/turkmen.html and http:// www.eia.doe.gov/emeu/ cabs/russia.html. [November 12, 1998]

[258] The estimated potential is given in Dorian et al, 51.

[259] For more on the proposed pipeline linkages in northeast Asia, see Paik and Quan; also Arlon R. Tussing, "Potential Boom Taking Shape In Developing Northeast Asian Natural Gas Supply Network," *Oil and Gas Journal* 96, no. 27 (July 6, 1998): 27-33; and Valencia, "Energy and Insecurity in Asia."

become a major player among world oil companies by outbidding all competitors for reserves in Central Asia, South America, Sudan, and other places. China views owning the oil as more secure than simply buying it on the open market, because this type of supply can only be cut off by extreme measures.

Additionally, this makes China a major investor in many of these countries. This connects these states and China economically, and makes it less likely that any of these states would automatically side with the U.S. or any other major power who had a disagreement with China and wanted to isolate it. Such an event may be unlikely, but as China and the U.S. are obtaining oil from many of the same places, interaction is inevitable. Based on the Chinese assumption that Western powers still want to keep China weak so it can be exploited, it is logical that China would take steps to be more secure in its supplies in these regions than the United States. By owning the reserves, China believes it is less likely to be affected by U.S. influence.

Some of these overseas deals have been discussed, specifically those in Central Asia. To obtain the rights to the Uzen field, CNPC bid 30% higher than its nearest competitor.[260] Many U.S. companies were vying for that contract, and this experience highlighted one cause for concern about China's energy policy. U.S. firms must comply with U.S. political restrictions designed to isolate countries like Iran and Iraq. China does not abide by such rules, and sees U.S. efforts to influence events in these countries as interference. In the Uzen deal, this difference helped clinch the deal for China. One part

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[260] See Rashid and Saywell, 46.

of the package CNPC offered Kazakhstan was the two pipelines previously mentioned. This provides the Kazakhs with export channels free from Russian influence. The pipeline through Iran is particularly attractive as this provides access to the Persian Gulf and markets in other Asian countries.

Central Asia is not the only place where Chinese gains have come at the expense of U.S. oil companies. In Venezuela—which is the largest supplier of U.S. oil imports—China beat out U.S. bidders again. This time, CNPC nearly doubled bids by U.S. oil companies, and for a price of $358 million (U.S.), obtained the rights to two separate blocks with estimated oil reserves of 100 Mtons.[261] The prices China is paying, and the expensive pipelines planned show the importance China is placing on securing diverse supplies. This reinforces the importance of security over affordability to China. With this approach as a *modus operandi*, it is doubtful that any other competitor can stand in China's way of obtaining reserves it desires. In the event that some country tried, the myriad of avenues China is pursuing should guarantee continuous flow of oil from somewhere, except in dire circumstances.

3. East and South China Seas

If such dire circumstances did occur, either due to foreign intervention or the complete failure of many overseas ventures, Beijing will look to other areas to meet its energy needs. A region that would begin to look more promising is the waters of the East and South China Seas. There has been much written about the disputes in the Spratly

[261] For more on this and other CNPC overseas acquisitions, see Rashid and Saywell.

Islands, and to a lesser extent the Diayou Islands, therefore only a brief review of the disagreements is necessary here.[262] The aspect of both disputes that is significant to this discussion is that both areas are believed to hide huge oil and gas reserves.

The Spratlys are the area that is most likely to appear valuable, even though the true extent of any reserves in the area is a complete unknown. China is just one of six countries that claims all or part of these islands. There has been much rhetoric thrown about and even some shots fired over the years. All sides see these islands as valuable and are unwilling to back down. "At this stage hopes, rather than solid evidence, of vast oil and gas reserves seem to be driving the action," and these hopes are huge.[263] Chinese sources have been quoted as saying that they expect oil and gas reserves in the area to be worth an estimated $1 trillion (U.S.).[264] Yergin, Eklof, and Edwards note that estimates of the oil reserves range from 6 to 105 billion barrels.[265] It is widely believed that the natural gas reserves exceed 65 trillion cubic meters, and may possibly contain another 25-50 trillion cubic meters.[266]

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[262] These are the two disputed areas in the region that China is most likely to view as having hydrocarbon potential on such a scale to warrant risking political fallout. For a discussion of some other possibilities, see Mark J. Valencia, "Energy and Insecurity in Asia."

[263] Susumu Awanchara, "Treacherous Shoals," *Far Eastern Economic Review* 155, no. 32 (August 13, 1992), 16.

[264] Ibid.

[265] Yergin, Eklof, and Edwards, 48.

[266] Ibid. For a detailed analysis of the undersea geography and oil exploration efforts in the region, see Mark J. Valencia, *South-East Asian Seas: Oil Under Troubled Waters, Hydrocarbon Potential, Jurisdictional Issues, and International Relations* (Singapore: Oxford University Press, 1985).

China has stayed involved in the islands, but has not been too forceful about its claims. If other options are shut off, the potential size of the resources in the area could drive China to consider becoming more aggressive about its rights in the area. The legality of these rights is somewhat vague, but so are the claims of all the other nations involved. The lack of clarity over the true legal status of these islands has led the U.S. to take a "hands off" approach to the whole affair.

If the situation escalated, many fear the U.S. would be dragged into the dispute because of the islands' strategic location near the major sea-lanes of the South China Sea. Almost all ships bound for Japan, Taiwan, or South Korea pass through this region carrying vital commodities, including over 70% of the oil and gas bound for these three countries.[267] Any disruption of this traffic would require a U.S. response under the current security guarantees to all three of these nations.[268]

The U.S. security guarantees to Japan are also a concern when examining the Diayou dispute. This island chain is the subject of competing claims by China, Taiwan, and Japan, who is the current controller of the chain. Once again, potential oil and gas reserves seem to be a motivating factor behind the dispute. While no major exploration

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[267] Yergin, Eklof, and Edwards, 49.

[268] For a reference to the importance of this area to the U.S., see "Prepared Statement of Stanley O. Roth, Assistant Secretary of State for East Asian and Pacific Affairs, for the House International Relations Committee, Asian and the Pacific Subcommittee," *Federal News Service*, (May 7, 1998), Available [Online]: Mead LEXIS/NEXIS/ASIAPC/ALLNWS/Spratly Islands

has been conducted in the islands, many believe the hydrocarbon potential may exceed that of the Spratlys.[269]

These areas are both encompassed by a very vague line drawn as part of China's 1992 Territorial Sea Law. This controversial law seemed to claim the entire East and South China Seas as Chinese territorial waters. Beijing's true intention with this law has never been fully clarified, but it is likely that the intent was to provide a basis for China to claim rights to any resources found in the area. In the past few years, Chinese officials have declined to elaborate on their claims, and there has been no incident to test their resolve. If China feels that possible resources in the area might be worth any politcal costs, this law could be given new teeth. This is a very unlikely scenario, but it could become less so depending on the success of China's other overseas ventures.

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[269] See Nathan and Ross, 155-118. For a discussion of the issues surrounding this dispute, see Alan J. Day (ed.), *Border and Territorial Disputes*, 2nd edition (Essex, UK: Longman Group Ltd, 1987), 286-287.

VIII. CONCLUSIONS AND RECOMMENDATIONS FOR U.S. POLICY

This thesis has explored two possible future scenarios for China's energy industry: high and low growth. The general trend is that if low growth occurs, China's actions will likely continue on a course quite similar to the one apparent today. There will be some changes in the energy sector, but overall needs can be met. If the high growth occurs, China will be faced with drastically increased oil and gas imports, and Beijing may fear the security implications that result from this dependence. This scenario could lead to tensions in the Middle East, Central Asia, and the South China Sea.

Fortunately, while China's economy is still growing, the rate of growth appears to be slowing. At the same time, the country is emphasizing efficiency and conservation. These efforts will help reduce the overall demand for energy supplies and slow the rate of growth in the energy industry. This makes the low growth scenario the most likely to occur. Even so, there will be an increase in demand for oil and gas imports that will have China interacting more frequently in world energy markets. Where there is interaction, there is always the possibility for disagreements. The U.S. must be sensible in dealing with China to keep Beijing comfortable with dependence on the world market. If disagreements are allowed to become conflicts, any alternative avenues that China may be likely to choose will be much more damaging to U.S. interests.

In the next few years, China's energy situation will evolve slightly. Oil is becoming increasingly important, and its share of TCEC will likely increase. This increase will be met by imports. Natural gas will also increase its share of TCEC though

very slowly. This could be accelerated, and most observers would like to see this done. The main barrier to this is China's emphasis on security above other concerns. This has led to actions that prevent China's indigenous gas industry from realizing its potential. These fuels will be in such high demand for industrial, transportation, and residential uses that they will not be available to assume greater shares of electrification.

In the electrical sector, China will continue to experience phenomenal growth rates. The share of capacity met by the various fuel sources will change slightly as nuclear power and hydropower increase their relative contributions. Commercial renewables will be unlikely to assume any significant portion of demand. However, these options need to be pursued as an avenue for relieving pressure to expend other fuel sources in rural areas. This can help keep the commercial energy growth rate near the low growth side.

The U.S. can assist China's electrical sector by further encouraging U.S. firms to participate in hydropower and nuclear plant construction. These are two areas that stand a realistic chance of increasing their percentage of TCEC, thereby reducing usage of coal. If planned goals are met in these two areas, the need to burn almost 70 Mtons of coal per year will be averted. These offer the best short-term chance for lessening China's impact on the environment. Fears of proliferation from peaceful nuclear power need to be overcome, and actions taken to encourage the growth of these industries. While many in the U.S. would like to see the role of nuclear power diminished in favor of natural gas power, this is not going to happen for many years in China. The U.S. should relax

restrictions on technology transfers for such items as high capacity power turbines, which can allow China to meet demand.

At the same time, the U.S. should step up its efforts to aid the Chinese in developing energy efficient technologies and practices. There are already many ventures in this area. One example can be found in *Climate Change Mitigation: Case Studies from China.*[270] This review of efforts by the Global Environmental Facility (GEF) provides an idea of the type of projects that can succeed in China given sufficient support. The U.S. needs to be one of these sources of support.

This program aids not only in reducing consumption but also, as the title implies, reducing environmental impact. This area will be the big challenge of the future. As China struggles to meet energy needs, coal will continue to play a dominant role. The U.S. needs to be proactive in encouraging China to adopt emission reduction technologies. To enable this, the U.S. will probably have to provide extensive assistance through the form of government subsidized corporate participation. U.S. firms are world leaders in developing technology in this area, but to encourage China to adopt these systems, demonstration units will likely have to be provided throughout the country. As local officials begin to see the possibilities, demand will likely grow.

Specifically applicable to coal use, the U.S. should provide extensive assistance to China in developing technology to lower sulfur content all through the coal usage cycle.

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[270] *Climate Change Mitigation: Case Studies from China*, AISU, Pacific Northwest National Laboratory (October 1997), Available [Online]: http://www.pnl.gov/china/chinacsf.pdf. [November 12, 1998]

An example of some programs that should be exported can be found in *Clean Coal Technology: Upgrading of Low-Rank Coals*.[271] These programs offer great potential in China where there is a great deal of low quality coal ore.

In summary, then, these suggestions represent little more than an extension of current Clinton administration approaches to China. Engagement is obviously the only real option. The question then becomes what form of engagement. Specifically, the U.S. must be as pragmatic as Beijing is becoming. China is going to get the energy it needs because this is a priority to the government. The U.S. has the power to treat China like a friend and help guide that country's transition to market dependence. Like all friendships, disagreement is inevitable, but this does not have to scuttle the benefits of continued relations. If the U.S. chooses to emphasize the differences between the two countries, and attempts to coerce China into desired behavioral patterns, the chance of success is slim. Nor are such efforts necessary. China is slowly evolving, and further engagement in the world economy can only accelerate this.

China's actions are not necessarily threatening to U.S. interests. A developed China is in everyone's interests, as this represents a large prosperous market. It also means that China will be more likely to transition to modern manufacturing methods and newer power plant designs which will reduce environmental degradation. But changes like these will only occur if China feels secure in relying on world markets for energy. If the U.S. and other countries see China's growth as threatening, China will likely react by

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[271] *Clean Coal Technology: Upgrading of Low-Rank Coals*, U.S. DOE Fossil Energy Topical Report no. 10 (August 1997), Available [Online]: http://www.fe.doe.gov. [November 10, 1998]

retrenching in traditional methods and by pursuing claims in the South China Sea and other areas. Essentially, as Jeffrey Bader, Assistant Secretary of State for East Asian and Pacific Affairs, stated: "to treat China as an enemy is to ensure that it will behave as one."[272] Bader went on to summarize the benefits of comprehensive engagement with China as follows:

> Our policy of comprehensive engagement is designed to pursue cooperation with China where appropriate while opposing those Chinese actions and policies with which we disagree. At the same time, we keep our eye on the long-term goal of bringing China firmly into the international system as a responsible participant. Only through a policy that engages China can we hope to accomplish these goals. We welcome a secure, prosperous and open China. Such a China will be a constructive member of the international community, and a valuable partner for the United States.[273]

What this thesis advocates then, is a broadening of those areas of cooperation deemed appropriate. U.S. policy tends to focus on proliferation concerns and environmental degradation, without really presenting the Chinese with any viable solutions. The U.S. must take the lead in helping China to find its way in the future energy market by helping to increase that country's confidence in market solutions. The true challenge will be in ensuring that policies are in place to continue such cooperation over a change of administration. This is where the Clinton administration must strive to

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[272] "Bader on Sino-American Relations: U.S. Policy Options," Testimony by Jeffrey Bader, Assistant Secretary of State for East Asian and Pacific Affairs, before the House International Relations Subcommittee on East Asian and Pacific Affairs (April 23, 1997), Available [Online]: http://www.pnl/gov/china/bader.htm, 1. [October 16, 1998]

[273] Ibid, 3.

build bipartisan support for engagement with China to prevent it from becoming a political tool. This would benefit neither party, and the whole world would pay the price.

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